A MANUAL OF BOTANY.

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A

MANUAL

OF

BOTANY:

INCLUDING THE

STRUCTURE, FUNCTIONS, CLASSIFICATION, PROPERTIES,

AND USES OF PLANTS.

BY

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PROFESSOR OF BOTANY AND MATERIA MEDICA TO THE PHARMACEUTICAL SOCIETY OF
GREAT BRITAIN: MEDICAL ASSOCIATE OF KING'S COLLEGE, LONDON.

Illustrated by nearly 1200 Woodcuts.

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MDCCCLXI.

TO

THOMAS BELL, Esq., F.R.S.

ETC. ETC. ETC.

President of the Linnean Society,

Professor of Zoology in King's College, London,

This Work is Dedicated,

AS A SMALL BUT SINCERE TRIBUTE OF ADMIRATION

OF HIS ABILITIES,

AND REGARD FOR HIS PRIVATE WORTH,

BY

THE AUTHOR.

PREFACE.

The principal design of the author in the preparation of the present volume was, to furnish a comprehensive, and, at the same time, a practical guide, to the Properties and Uses of Plants, a part of Botany which, in the majority of manuals, is but very briefly alluded to. He hopes that in this respect the present manual may serve as an introduction to works devoted particularly to Materia Medica and Economic Botany, and thus form a text-book of especial value to medical and pharmaceutical students; as well as a work of reference generally, for those engaged in commercial pursuits who have daily to make use of substances derived from the vegetable kingdom.

Another prominent motive of the author was, to furnish the pupils attending his lectures with a class-book, in which the subjects treated of should be arranged, as far as possible, in the same order as followed by him in the lectures themselves. It may be noticed that this order differs in several respects from that commonly followed, but long experience as a teacher has convinced him that it is the most desirable one to be followed by the student. Great pains have been taken in all departments to bring the different subjects treated of down to the present state of science; and much care has been exercised in condensing the very numerous details bearing upon each department, and in arranging them for systematic study.

The author makes no claims for this work to be regarded as a complete treatise on the different departments of Botany; it is

only intended as a guide to larger and more comprehensive works, but he trusts, at the same time, that it will be found to contain everything which the student of botany really requires, whether he is pursuing it as a branch of professional or general education, or for pleasure and recreation.

The vast number of facts, observations, and terms necessarily treated of, in the departments of Structural, Morphological, and Systematic Botany, have compelled the author to give but a brief account of the Physiology of Plants; he hopes, however, that even here, all the more important subjects bearing upon the education of the medical practitioner and pharmaceutist will be found sufficiently comprehensive. To those who require a more complete knowledge of this department he would refer them to the Second Part of Balfour's Class-Book of Botany, in which valuable work full details upon Physiological Botany will be found.

The author had a great desire also, to include in the present volume, an Appendix upon Descriptive Botany, and a Glossary of Botanical Terms, but the manual having already exceeded the limits desired, he is unable to do so. The index itself, will, however, serve as a glossary by referring to the pages in which the different terms are defined and explained; and with regard to Descriptive Botany, the author would especially recommend every reader of this work to obtain a small but very valuable work on that subject which has been recently published by Dr. Lindley.

In compiling this volume the author has been necessarily compelled to refer to many works and original memoirs on botanical science, and he hopes that in all cases he has given full credit to the different authors for the assistance they have afforded him. If he has omitted to do so in any instance, it has arisen from inadvertence and not from design. To the valuable works of Mohl, Jussieu, Schleiden, Mulder, Hofmeister, Asa Gray, and Schacht, amongst foreign botanists; and to those of Lindley, Balfour, Henfrey, Hooker, Berkley, Pereira, and Royle, amongst British botanists, he begs to express his obligations. To my friend, Mr. Daniel Hanbury, I am also indebted for some valuable information communicated during the progress of the

work. To Lindley's Vegetable Kingdom, Pereira's Materia Medica, and to the many valuable articles upon the Anatomy of Plants in Griffith's and Henfrey's Micrographic Dictionary, by the lamented Henfrey, the author is more especially indebted. The last three works will always bear ample testimony to the great research and abilities of their respective authors.

The author has further to express his obligations to his spirited publisher, for the numerous woodcuts which he has liberally allowed him, and to Mr. Bagg for the great skill he has shown in their execution. A large number of these woodcuts have been taken from Maout's Atlas Élémentaire de Botanique; several from Jussieu's Cours Élémentaire de Botanique; others have been derived from the works of Schleiden, Mohl, Hofmeister, Lindley, Henfrey, Balfour, &c.; and many are from original sources. By the judicious use of these woodcuts in the text of the volume, it is believed that the value of the work as a class-book of botanical science has been materially increased.

LONDON, *May* 1, 1861.

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CORRECTIONS AND ADDITIONS.

Page 9, line 27 from the top, *after* adopted, *insert*:—The recent important investigations of M. Frémy lead to the conclusion, that cellulose exists in several isomeric conditions, which differ materially in their chemical properties; thus, he has noticed four different kinds of cellulose, which he has termed respectively, *cellulose*, *para-cellulose*, *vasculose*, and *fibrose*. The *first* exists, according to him, in the cell-walls of the albumen of certain seeds, in those of cotton, and in liber-cells; the *second* in the pith and medullary rays; the *third* in the vessels generally; and the *fourth* in the ordinary wood-cells. The first is soluble in cuprate of ammonia; but the other kinds are insoluble.

Page 20, line 26 from the bottom, *after* O^8, refer to page 744 for more recent investigations upon Chlorophyll.

Page 21, line 6 from the top, *after* plants, *omit* except the Fungi.

Page 22, line 22 from the top, *after Carex arenaria*, *omit* the next sentence, and *insert instead*, also by Currey and Tulasne in certain Fungi, and by Schenck in *Ornithogalum nutans* and *O. lanceolatum*.

Page 26, line 4 from the top, *for* oxalate *read* carbonate.

Page 31, line 8 from the top, *for Fig.* 56 *read Fig.* 57; *also*, same page, *for Figs.* 56 and 57 *read Figs.* 57 and 56.

Page 37, line 21 from the bottom, *after Fig.* 75, *insert*:—M. Frémy has recently made some experiments upon the *latex*, and he states, that he has found in certain plants, a kind of latex as albuminous as the serum of the blood or the albumen of the egg, and to which he has given the name of albuminous latex. Should his experiments be confirmed, they will have a most important bearing on vegetable physiology, as they will prove that the latex, contrary to what has been generally believed, is a truly organizing liquid resembling in composition the organs in process of formation.

Page 38, line 10 from the top, *after* spiral, *insert* and the other vessels. (See also page 728 for a further notice of Trécul's observations.)

Page 49, *Fig.* 116, *put b* over the two right hand figures.

Page 57, line 9 from the top, *for* p. 7 *read* p. 17.

Page 163, line 1 at the top, *after* some kinds of Senna *erase* (Cassia obovata); and in description of *Fig.* 313, *a*, *for* leaflet of *Cassia obovata read* leaflet of a species of *Cassia*.

Page 248, line 5 from the bottom, *erase* and Tulip (*Fig.* 510).

Page 249, in description of *Fig.* 510, *for* innate, *read* introrse.

Page 255, line 7 from the top, *for Fig.* 520, *read Fig.* 530.

Page 266, line 6 from the top, *for* that volume, *read* this volume.

Page 316, *Fig.* 684 is inverted.

Page 333, *for Fig.* 719, *put Fig.* 720.

Page 333, *for Fig.* 720, *put Fig.* 719.

Page 437, *before* Xanthorrhiza insert:—*Actæa*, or *Cimicifuga racemosa*. The rhizome and radicles of this plant have been lately employed with great success both in the United States of North America and in this country in acute rheumatism, chorea, &c. (See paper by the Author in the *Pharmaceutical Journal*, vol. ii. ser. 2, p. 461.)

Page 478, line 14 from the bottom, *after* perfumery, *insert* The Nag-kassar, which was imported into England some years since, is the produce of *Calysaccion longifolium*. It is chiefly employed in India for dyeing silk. In India the term Nag-kassar is applied, not only to the dried flower-buds of this plant, but also to those of two or more species of *Mesua*, and other Clusiaceæ.

Page 502, line 25 from the bottom, *after* by, *insert* no.

Page 512, line 24 from the bottom, *insert* after Cape of Good Hope. From the leaves of a variety of *Pelargonium Radula*, and also from some other species or varieties of *Pelargonium*, a true essential oil of geranium is obtained by distillation. It is used in perfumery, &c.

Page 591, line 6 from the bottom, *for* but the, *read* both the.

Page 619, heading of page, for Monochlamydeæ *read* Corolliflorae.

MANUAL OF BOTANY.

INTRODUCTORY REMARKS.

Natural History, as a science, has for its object the investigation of every thing that relates to the bodies placed on the surface of the globe; or combined so as to form its substance. These in common language, and by the scientific observer, are divided into three great divisions ; called, respectively, the Animal, Vegetable, and Mineral kingdoms. The bodies comprised in the two former, being possessed of life, form the Organic or Animate creation; while those of the latter, not being endowed with life, form the Inanimate or Inorganic creation. It is our province in this work to treat of the lower ranks of the organic creation, called Plants or Vegetables. The science which investigates these is termed Botany, from the Greek word βοτάνη, signifying an herb or grass.

Departments of Botany.—This science in its extended sense embraces everything which has reference to plants, either in a living or fossil state. It investigates their nature; their internal organization; their external configuration; the laws by which they are enabled to grow and propagate themselves; and their relations to one another, and to the bodies by which they are surrounded. As a science, therefore, it is of vast extent, and one which requires for its successful prosecution the most careful and systematic study. It may be divided into the following departments:—1. *Organography;* this includes everything which relates to the internal structure and external configuration of plants, and their various parts or organs ; the portion of the subject treating of their structure is commonly termed *Structural Botany;* and that which has reference to their forms, *Morphological Botany.*— 2. *Organology* or *Physiological Botany;* this treats of plants, and their organs, in a state of life or action. 3. *Systematic Botany;* this considers plants in their relations to one another, and comprehends their arrangement and classifica-

tion. 4. *Geographical Botany* is that which explains the laws which regulate the distribution of plants over the surface of the globe at the present time; and 5. *Palæontological* or *Fossil Botany* is that department which investigates the nature of the plants which are found in a fossil state in the different strata of which the earth is composed.*

DISTINCTIONS BETWEEN ANIMALS, PLANTS, AND MINERALS.—Botany being the science which treats of plants, we ought to commence our subject by defining what we mean by a plant. No absolute definition can, however, be given in the present limited state of our knowledge. We have, it is true, no difficulty in distinguishing a plant from a mineral; for the possession of individual life and power of reproduction in the former, form at once, without further investigation, a broad and well-marked line of demarcation from the latter: and even when we compare a plant with an animal, so long as we confine our researches to the higher members of the two kingdoms, the distinctions are evident enough; difficulties only occur when we look deeply into the subject, and compare together those bodies which are placed lowest in the scale of creation, and stand as it were on the confines of the two kingdoms. It is then that we find the impossibility of laying down any certain characteristics by which the two may be absolutely recognised: we shall at present, therefore, only allude to those characters by which plants may in a general sense be distinguished from animals, leaving the more extended investigation of the subject to the pages of this volume.

In the first place, we find that plants hold an intermediate station between minerals and animals, and derive their nourishment from the earth and the air by which they are surrounded, and that they alone have the power of converting inorganic or mineral matter into organic. Animals, on the contrary, consume organic matter, and reconvert it into inorganic. In other words, plants produce organic matter, and animals consume it.

Secondly, plants are generally fixed to the soil, or to the substance upon which they grow, and derive their food immediately by absorption through their external surface; while animals, being possessed of sensation and power of voluntary motion, can wander about in search of the food which has been prepared for them by plants, which they receive into an internal cavity or stomach. Plants are, therefore, to be regarded as destitute of sensation and power of voluntary motion, and as being nourished from without; while animals are possessed of those attributes, and are nourished from within.

* The first three departments are those only that come within the scope of the present work; the latter being of too extensive a nature to allow of being treated of satisfactorily within the necessary limits of a student's manual.

Thirdly, in respiration, or more properly assimilation, plants decompose carbonic acid, fix the carbon which is the result of that decomposition in their tissues, and restore the oxygen to the atmosphere. The respiration of animals, on the contrary, consists in the expiration of carbonic acid, which is formed by the combination of the carbon which the animal system wants to throw off with the oxygen absorbed from the atmosphere. Plants therefore, in respiration, absorb carbonic acid and eliminate oxygen; while animals absorb oxygen and eliminate carbonic acid.

Fourthly, there is a difference in the ultimate elements of the permanent tissues of plants and animals; for while those of the former consist only of three elements, namely, carbon, oxygen, and hydrogen; those of the latter are composed of four, namely, carbon, oxygen, hydrogen, and nitrogen.

In reference to the above distinctive characters, it must be particularly remarked that they are only general, namely, those derived from comparing together, as a whole, the members of the animal and vegetable kingdoms. To all of the above characters there may be found some exceptions, when we compare particular individuals. For their elucidation, however, we must refer to the general contents of this volume.

It was formerly believed that an absolute distinctive character existed between plants and animals, in the cells of the former consisting essentially of cellulose, while those of the latter were formed of gelatine. The recent researches of Schmidt, Löwig, Kölliker, Schacht, Virchow, Huxley, and others, have, however, shown that cellulose also exists as a constituent of several animals. The presence of starch was also formerly considered as a certain characteristic of a plant, but recent investigations have also shown that that substance, or at least one isomeric with it, is also to be found in some animals. Neither the presence of cellulose or starch can be now considered, therefore, as presenting any absolute marks of distinction between plants and animals. We arrive accordingly at the conclusion, that in the present state of our knowledge, it is impossible to give a complete and perfect definition of a plant, in contradistinction to what is to be regarded as an animal.

BOOK I.

ORGANOGRAPHY; OR STRUCTURAL AND MORPHOLOGICAL BOTANY

The most superficial examination of any common plant enables us to distinguish various parts, such as the root, stem, leaves, &c.; if more minutely examined, it will be found that these parts are not themselves elementary, but that they are also made up of others, in the form of little membranous sacs, and tubes, of different sizes and shapes, combined together in various ways. Before we examine therefore the more evident, or as they are called, compound organs of the plant, it will be necessary for us to explain fully the elementary structures of which they are composed. This division of our subject is termed Vegetable Histology.

CHAPTER 1.

ELEMENTARY STRUCTURE OF PLANTS, OR VEGETABLE HISTOLOGY.

Section 1. Of the Cell as an Individual.

All plants in their earliest condition are composed of one or more delicate membranous closed sacs, called *cells* or *utricles*. All the organs which afterwards make their appearance in the plant are also made up of these little bodies, variously modified according to circumstances. The simple cell presents itself, therefore, as the first and most important organ of the plant; that from which all the others are developed; and, consequently, the only real elementary organ possessed by it. It demands therefore our particular investigation. In treating of it, we shall first describe its *form* and *size;* then *proceed to investigate* the nature of the *membrane* of which it is composed; and lastly, its *contents*.

1. Form of the Cell.—The cell in its earliest condition consists of an exceedingly thin structureless membrane, enclosing various substances. When developed in a space where it is perfectly free from the pressure of surrounding bodies, and when equally nourished at all parts of its surface, it assumes a more

or less rounded form (*fig.* 1); the sphere is therefore to be considered as the typical form of a cell. This tendency, however, of cells to assume a spherical form must be received with some limitation, it being distinctly understood that such will be the case only, when they are developed under the above conditions. But in the great majority of cases, as cells are formed by the division of older cells (as will be hereafter seen), it must necessarily happen, that when first developed they will have the shape of the half, the quarter, or some other section of the parent cell, according to the number of parts into which it may be divided. Such cells, however, if unrestricted in their after-development, will then tend in the majority of cases to assume a spherical

Fig. 1.

Fig 2.

Fig. 3.

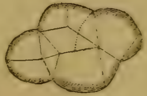


Fig. 4.

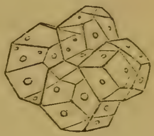


Fig. 5.

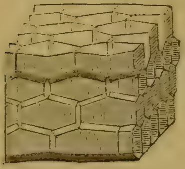


Fig. 1. **Rounded cells.**

Fig. 2. **Elliptic or oblong cell.**

Figs. 3, 4, and 5. **Polygonal cells.**

form. But, in consequence of cells being usually developed in a confined space, a number of other forms are produced, all of which depend upon two circumstances. In the first place, the form is determined by the unequal nutrition to which the different parts of the cell-wall are subjected, thus causing a corresponding irregular growth; and secondly, from the varying pressure of the surrounding organs. We shall now allude to a few of the more common forms which cells assume.

First, when the nutrition is uniform, or nearly so, on all points and sides of the cell-wall, we have a *spherical* or slightly *elliptic* cell (*fig.* 1): when it is greater at the two extremities than at the sides, the form is truly *elliptic* (*fig.* 2). In the above cases, also, the cells are almost free from pressure. Under other circumstances, in consequence of the mutual pressure of surrounding cells, they assume a *polygonal* form (*figs.* 3, 4, and 5), the number of the angles depending upon the number and arrangement of the contiguous cells. Thus, in a per-

fectly regular arrangement, when the contiguous cells are of equal size, we have *dodecahedral* cells, presenting, when cut transversely, a hexagonal appearance (*fig.* 5). It is rarely however that we find cells of this regular mathematical form, since, in consequence of the unequal size of the contiguous cells, the polygons which result from their mutual pressure must be more or less irregular, and exhibit a variable number of sides (generally from three to eight) (*fig.* 4).

Secondly, when the nutrition is nearly uniform on all sides of the cell-wall, but not equally so at all points of its surface, we have cells which maintain a somewhat rounded form in the centre, but having rays projecting from them in various directions, by which they acquire a somewhat star-like appearance (*fig.* 6); and hence such cells are called *stellate.* These rays may be situated in one plane, or project from all sides of the cell. It is rarely the case that such cells have the rays at regular intervals, or all of one length, but various degrees of irregularity occur, which lead to corresponding irregular forms in such stellate cells.

Fig. 6.

Fig. 6. Stellate cells.

Thirdly, when the nutrition occurs chiefly in one direction we have cells which are elongated, either horizontally or vertically. Among the forms resulting from an extension of the cell in breadth or in a horizontal direction, we need only men-

Fig. 7.

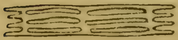


Fig. 8.

Fig. 9.

Fig. 10.

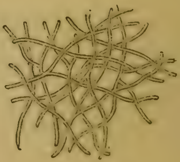


Fig. 7. Tabular cells.——*Fig.* 8. Cylindrical cells. The small or rounded body in the interior of three of them is called a nucleus or cytoblast. ——*Fig.* 9. Elongated fusiform cells.——*Fig.* 10. Fibrilliform cells.

tion *tabular* cells (*fig.* 7), that is six-sided flattened cells, with the upper and lower surfaces parallel, or nearly so. Of those cells, which are extended in length or vertically, we have various forms, as *cylindrical* (*fig.* 8), *fusiform* (*fig.* 9), *fibrilliform* (*fig.* 10), &c.; the two former, by the mutual pressure of contiguous cells, often become *prismatic.*

From the above description of the forms of cells it will be seen that they may be divided into the *short* and *elongated*, although, as various intermediate forms occur, this division cannot be strictly adhered to.

The cells, when in combination with other cells, are generally bounded by plane or rounded surfaces (*figs.* 1 and 5): but when in combination also with the vessels of the plant, so as to form what are called the *vascular bundles*, they are elongated, and have pointed extremities (*fig.* 9). These differences in the condition of the cells lead to corresponding differences in their arrangement; thus, in the former case, the cells, when arranged in lines, are placed one upon another, the ends being usually flattened (*fig.* 8); while in the latter their tapering extremities overlap one another, and become interposed between the sides of the cells which are placed above and below them (*fig.* 9). From this circumstance cells have been divided into *parenchymatous* and *prosenchymatous*; parenchymatous being the term applied to those cells which are placed end to end; and prosenchymatous to those which are attenuated, and overlap one another when combined together to form a tissue. Another distinction commonly observed between parenchymatous and prosenchymatous cells arises from the condition of their cell-walls; thus, those of parenchymatous cells are usually thin and but little incrusted; while those of prosenchymatous cells are more or less thickened by the deposition upon their inner surfaces of various incrusting matters. The above distinctions between parenchymatous and prosenchymatous cells are evident enough in the extreme forms of the two divisions, but various transitional states occur which render it impossible to draw, in many cases, a distinct line of demarcation between them.

The above-mentioned forms of cells are the principal ones which occur when they are in combination so as to form a tissue; but it may be readily understood that many others are found, which arise from various irregularities in the pressure and nutrition of the cells.

We must now briefly allude to a few of the forms which cells assume when not in combination, or but partially so, under which circumstances they are more or less unrestrained in their development. In these cases, as in the former, the typical form of the cells is to be spherical, but this form is rarely maintained as they grow older, although instances of such occur frequently in

pollen (*figs.* 11 and 12); in the spores of many of the lower Algæ, as *Protococcus* (*fig.* 148), &c. More frequently, however, the cells assume a more or less elongated form (*fig.* 13) and become oblong or cylindrical. In other cases again, we find that certain points of the cell-wall acquire a spherical development, and become elevated from its general surface as little papillæ (*fig.* 13), or ciliæ (*figs.* 14, 15, and 16), or are prolonged into tubular processes, or branched in various ways. The hairs produced on the surface of plants will afford us good illustrations of such cells (*figs.* 96—99); other instances occur in

Figs. 11 and 12.

Figs. 11 and 12. Spherical pollen cells.

Fig. 15.

Fig. 14.

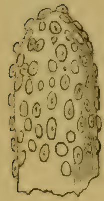


Fig. 13.

Fig. 16.

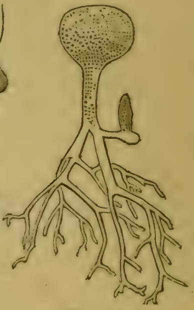


Fig. 17.

Fig. 13. Elongated cell covered with warty projections.——*Figs.* 14, 15, and 16. Ciliated cells.——*Fig.* 17. Branched cell (*Botrydium granulatum*).

the germination of most spores, and strikingly so in those of many Algæ, as *Botrydium* (*fig.* 17); also when the pollen cells fall upon the surface of the stigma; and numerous other illustrations will be observed as we proceed with our subject.

2. Size of the Cell.— The cells vary much in size in different plants, and in different parts of the same plant. The parenchymatous cells, on an average, vary from about $\frac{1}{250}$ to $\frac{1}{1200}$ of an inch in diameter; others again are not more than $\frac{1}{5000}$; while in some cases they are so large as to be visible to the naked eye, being as much as $\frac{1}{50}$ or even $\frac{1}{30}$ of an inch in diameter. The largest occur in the pith of plants, in succulent parts, and in water plants.

The dimensions of prosenchymatous cells generally afford a great contrast to those of the parenchymatous, for while we find that their transverse diameter is commonly much less, they become

much more extended longitudinally, some having been measured as much as $\frac{1}{4}$ of an inch long, and there is no doubt but that those of the inner bark of the flax and hemp plants are even much longer. The prosenchymatous cells of the wood and inner bark of trees generally vary however, from about the $\frac{1}{40}$ to the $\frac{1}{12}$ of an inch in length.

Those cells again which have an unrestrained development are frequently also far more extended in length. Thus, the cells of which cotton is formed are sometimes as much as one or two inches long, while in the lower Algæ, as *Chara*, cells occur several inches in length.

3. THE CELL-MEMBRANE OR CELL-WALL.— a. *Its Chemical Properties.*—The membrane of which the cell is composed consists of the substance called *cellulose*, and as all plants and all parts of a plant are formed essentially of cells variously modified and combined, this substance must be considered as the fundamental material of the plant. When pure it is a ternary compound of *carbon*, *hydrogen*, and *oxygen* ; of which the latter two exist in the same proportions as in water. Hence it may be considered as consisting of carbon and the elements of water. The formula of cellulose, according to Payen, is $C_{12}\ H_{10}\ O_{10}$; it is thus closely allied in composition to starch, if not actually isomeric with it. According to Mulder, however, the formula of cellulose, as shown by the experiments of Fromberg, is not $C_{12}\ H_{10}\ O_{10}$, but $C_{24}\ H_{21}\ O_{21}$; agreeing, not with starch, but with soluble inuline, which has a similar composition. The formula of Payen is that however which is generally adopted.

Cellulose is insoluble in both cold and boiling water ; also in alcohol, ether, and dilute acids, and almost insoluble in weak alkaline solutions. By the action of concentrated sulphuric acid and caustic potash, it is changed into dextrine. When iodine and sulphuric acid are applied to it, it assumes an indigo blue color, which is rendered more evident if the sulphuric acid be previously diluted with water (the best proportions being one part of the latter to three of the former). A similar blue colour is also produced, as first shown by Schultz, when cellulose is moistened with a solution of chloride of zinc, iodine, and iodide of potassium.* Mohl has also shown that cellulose will assume a blue colour if it be thoroughly imbued with iodine, and afterwards moistened with water. The blue colour will not be produced however, under such circumstances, when we operate upon the cell-membrane of very young cells, hence it is probable that the young cell-membrane may be composed of a substance

* This solution may be thus prepared.—Dissolve zinc in hydrochloric acid; then evaporate the solution in contact with metallic zinc to the thickness of a syrup ; the syrup is then to be saturated with iodide of potassium ; after which iodine is added, and the solution, when necessary, is diluted with water.

differing from cellulose, and which afterwards becomes changed into it.

It rarely happens that cellulose can be found pure in any cell-membranes ; it is usually combined with various organic and inorganic substances, which modify the action of the above reagents, and thus explain the differences which we find to exist in the chemical properties of the membranes of the cells of different plants, as well as those exhibited by the same cells at different periods.

Cellulose, as we have already seen, was formerly thought to be a substance peculiar to plants, but it has now been found by several observers in the tunics of some molluscous animals, and in some of the organs of the higher animals.

b. *Its General Properties and Structure.*—The membrane constituting the walls of young cells is transparent, and generally colourless, although exceptions to this latter condition occasionally occur, especially in the lower orders of plants. As the cells increase in age, they frequently assume a yellow, red, or brown tint, in consequence of their walls absorbing those different colouring matters. When the cell-walls become thus coloured, they commonly lose in a great degree their transparency. The various colours which the different parts of the plant assume, as the vivid tints of the corolla, and the green of the young bark and leaves, are not owing, therefore, to original differences in the colour of the membranes of the cells of which those parts are respectively composed, but to the different colouring matters which those cells contain.

The cell-membrane of young cells is very thin, smooth, and free from any openings or visible pores, so that each is a perfectly closed sac. The membrane, however, although free from visible pores, is readily permeable by fluids, as is the case with all organic membranes. Some observers, as Mulder, Hartwig, and others, have described it as perforated like a sieve, but such a view, as shown by Mohl, has arisen from imperfect observation. The causes which give rise to the appearance of pores will be described presently. It is, however, quite true that in the membrane of old cells perforations do occasionally occur, as in the leaves of *Sphagnum*, and in some other cases. In the *Sphagnum* the holes in the cell-walls are sufficiently large to allow of the passage through them of animalcules and minute granular matters.

As the cell-membrane increases in age it becomes thickened, and the cells of which it is composed increase in size. This takes place at first by the incorporation of new matter in its substance, or *interstitially*; but after the cells have arrived at a definite size, in all cases where they form parts of the permament structure of plants, their membranes increase in thickness, not however as in the former case by interstitial deposition, but

by the successive deposit of new matter upon their inner surface. This new matter is generally deposited in layers proceeding from without inwards, which thus gradually diminish the cavity of the cell, and even in many cases cause it to be completely or nearly filled up (*fig.* 18). This increase in thickness may be especially observed in the cells of the wood and inner bark; also in the hard cells of the stone of the peach, cherry, and other similar fruits, as well as in the shells of many other fruits. This thickening however of the young cell-membrane, by successive layers of deposit in its interior, is by no means confined to the cells of the wood, or the other cases above mentioned, but it may be observed more or less in all cells where active chemical changes are going on. Thus it may be especially seen in those of the pith of *Hoya carnosa* (*fig.* 18). It is these deposits which give hardness and firmness to the wood of plants and to the stones of fruits, and hence the name of Sclerogen (from a Greek word signifying hardness) has been given to them. The term Lignine is also frequently applied to them from their common occurrence in wood. Whether Sclerogen or Lignine be essentially different in its chemical composition to cellulose has not been fully ascertained; but, according to Mulder, there are three or more definite compounds forming the incrusting layers of the cells of the wood and other parts, all of which are richer than cellulose in carbon and hydrogen. Further experiments are wanted before we can arrive at any definite conclusions on the above points.

Fig. 18.

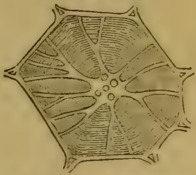


Fig. 18. Transverse section of a thick-walled cell of the pith of *Hoya carnosa*. From Mohl.

These thickening layers, which are commonly called secondary layers or deposits, never consist however of pure Lignine or Sclerogen, but they contain, combined with it, various mineral substances, which have been absorbed dissolved in water by the roots of the plant, and deposited in those layers in the passage of the fluid through the cells ; also various organic products, as colouring matters, &c., which have been formed in the cells themselves, or have been conveyed to them from other parts.

Porous, Pitted, or Dotted Cells.—In almost all cases where the cell-membrane has thus become thickened by incrusting matters, it presents (instead of the smooth and uniform appearance, as is the case, as we have seen, when it is in a young condition) a greater or less number of dots, pits, or slits of various kinds (*figs.* 19 and 20, *e*), which were formerly considered as actual openings in the walls of the cells, and hence

these were called *porous cells;* but, when carefully examined, it may be readily discovered that this dotted appearance is caused

Fig. 19.

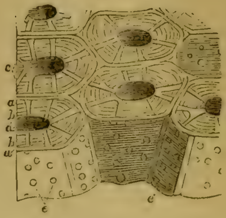


Fig. 20.

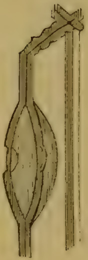
Fig. 19. Pitted cells.——*Fig.* 20. Thick-walled cells from the fruit of a palm. *a.* Original cell-walls. *b.* Secondary layers. *c.* Pit canals. *d.* Cavity of the cell. *e.* External pitted appearance. (From Unger.)

by canals which run from the outer cell-membrane (*fig.* 20, *a*) formed of cellulose, through the layers of thickening (*b*), and open into the cavity of the cell (*d*), and thus give a more transparent appearance, when viewed by transmitted light, to the cell-membrane in which they are found, to that of the surrounding thickened membrane. We arrive therefore at the conclusion, that the successive deposits of thickening layers take place, not as imperforate membranes, as is the case with the primary cell-membrane, but as perforated ones, which are deposited in succession from without inwards, in such a manner that the openings in each of them shall exactly correspond the one to the other, so as to form continuous canals from the cavity of the cell towards, or to, the primary cell-membrane which bounds those canals on the outside. Such cells are therefore improperly called porous, and hence are now commonly and correctly termed *pitted* or *dotted* cells. The pits or canals of contiguous cells generally accurately correspond, so that however the cell-walls may become thickened, their cavities are only separated from each other at such spots by their primary thin walls (*fig.* 20, *a*), a contrivance especially designed to admit of a free communication between the cells, notwithstanding the thickening which their walls have undergone. It frequently happens that two or more canals unite together at varying distances from the walls of the cell, and thus form a common opening into its cavity (*fig.* 18).

Although we have thus shown that the dotted appearance is not caused by external holes or perforations in the primary walls of the cells, yet as the latter advance in age, and lose their active vitality, they frequently become perforated, in consequence of their thin primary membrane becoming absorbed or breaking away.

Cells with Bordered Pores.—In the wood-cells of some trees we find their walls present, in addition to the ordinary pits, large circular dots or discs which encircle them, so that each pit looks as if it had a ring surrounding it (*fig.* 21); hence such cells have been termed *cells with bordered pores or pits*, or *disc-bearing wood-cells*, or *punctated wood-cells.* Such an appearance is produced by the walls of the cells having a number of circular depressions on their outside, each of which is shaped like a watch-glass (*fig.* 22). When two cells lie side by side, the

Fig. 21. *Fig.* 22. *Fig.* 23.



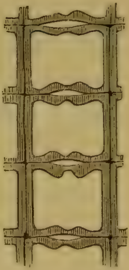


Fig. 21. Disc-bearing wood-cells of the pine, with a single row of discs on each cell.——*Fig.* 22. Diagram showing the watch-glass depression on the outside of a wood-cell of the pine.——*Fig.* 23. Diagram showing disc-bearing wood-cells in combination.

depressions on the one accurately correspond to those upon the other (*fig.* 23), by which a number of lenticular cavities are formed between them, so that when viewed by transmitted light they appear like discs. The central pit is formed in the same manner, and owes its appearance to the same cause which leads to the ordinary pit of cells. The existence of these lenticular cavities between the sides of certain cells was first accurately proved by the late Edwin Quekett, who succeeded in separating from the discs of a piece of fossil wood, double convex masses of solid matter.

Cells presenting such an appearance appear to be of universal occurrence in the wood of the Coniferæ or cone-bearing plants, where they are also most distinctly observed. It was formerly supposed that they were confined to such plants, but it has now been proved that similar discs also exist in the wood-cells of some other trees. Thus in the Winter's Bark Tree (*Wintera aromatica*) and in the Star Anise (*Illicium floridanum*) such discs may be observed (*fig.* 24), but the central pit is absent in these cases.

These discs occur either in single rows (*fig.* 21), or in double (*fig.* 25), or in triple rows (*fig.* 28); in the latter cases the discs in each row may be either on the same level, as is more com-

Fig. 24.

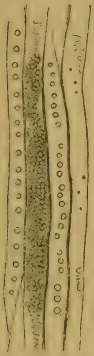


Fig. 25.

Fig. 26.

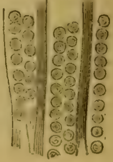


Fig. 28.

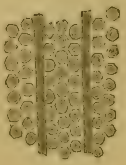


Fig. 27.

Fig. 24. Wood-cells from *Illicium floridanum*. From Gray.
Fig. 25. Disc-bearing wood-cells of the pine, with a double row of discs. After Nicol.——*Fig.* 26. Disc-bearing wood-cells of *Altingia excelsa*, with double rows of discs, which are alternate with each other.——*Fig.* 27. Disc-bearing wood-cells of the Weymouth pine (*Pinus Strobus*), with double rows of discs, which are on the same level, or opposite to each other. After Nicol.——*Fig.* 28. Disc-bearing wood-cells of Araucaria, with double and triple rows of alternate discs. After Nicol.

monly the case (*figs.* 25 and 27), or at different levels, and hence alternate to each other, as in the Araucarias and allied trees (*figs.* 26 and 28). These discs are commonly found in the sides of the wood-cells which are turned towards the silver-grain of trees (see p. 83); while the ordinary pits of wood-cells are generally more abundant on the sides looking towards the centre and circumference of the tree.

The cause which leads to the formation of these lenticular cavities has not yet been clearly proved. According to Schleiden, they arise from the occurrence of bubbles of air between the walls of the cells in which they are found; but Mohl states that such an assertion is incorrect, for such cavities are filled with sap in the young condition of the cells, which indeed may be seen by any one with ordinary care.

Fibrous Cells.—It frequently happens that the secondary layers (instead of being deposited in the form of perforated

membranes, which give rise to the pitted cells already described), consist of delicate threads or bands of varying thickness called *fibres*, which assume a more or less spiral direction upon the inner surface of the primary cell-membrane (*figs*. 29-31), and thus give rise to what are called *fibrous cells*. In most cases the fibres are wound to the right, although instances occasionally occur where they turn in a contrary direction. Such fibrous cells occur in various plants and parts of plants; thus in the leaf of the *Sphagnum*, the hairs of many *Cacti*, in some of the membranes of many seeds, as those of *Salvia*, *Collomia*, &c.; in the spore-cases of some of the Flowerless Plants, in the inner lining of all anthers, in the outer rind of the aerial roots of many Orchids, and in many other instances.

These fibrous cells also present some differences of appearance as regards the distribution of their fibres. Thus, in some cells the fibre forms an uninterrupted spiral from one end to the other (*fig*. 29): such are termed *spiral cells*. In other cases the fibre is interrupted at various points, and assumes the form of rings upon the inner surface of the cell-wall (*fig*. 30), and hence such cells are called *annular* or *ringed*. Instances also occur even more frequently, in which the fibres are so distributed as to produce a branched or netted appearance (*fig*. 31); such cells are termed *ramified* or *reticulated*. These annular and reticulated cells are merely modifications of the spiral, as is shown by the circumstance of our frequently finding in the same cell intermediate conditions of all these forms. (For further particulars on this head see Annular and Reticulated Vessels.)

Fig. 29. *Fig*. 30. *Fig*. 31.

Fig. 29. Spiral cell.——*Fig*. 30. Annular or ringed cell.——*Fig*. 31. Ramified or reticulated cells.

The turns of the fibre, or the rings, may be nearly in contact, or more or less separated by intervals of cell-membrane; which latter appearance is probably due to the growth of the membrane after the deposition of the fibre. The turns of the fibre, or the rings, again, may be either intimately attached to the cell-membrane, or but slightly adherent, or altogether free. As a general rule, the less the cell-membrane grows after the deposition of the fibre, the more firmly is it attached to it.

These different kinds of fibrous cells are connected by a number of intermediate forms with the pitted cells already treated of (*fig*. 32); and hence it has been supposed by many that the secondary layers which give rise to the latter structures

are also deposited originally in a spiral direction, and in fact that all secondary deposits have a tendency to assume a spiral arrangement. The great advocate of such a theory is Schleiden. He believes that after the cell-membrane has ceased to grow by interstitial deposition, an important change takes place in the mode in which it is nourished, all additions to it being then made in successive layers upon its inner surface. These layers are not however deposited as continuous membranes, but as spiral fibres or bands. If the cell distends after such deposition, then the spires which were originally placed close together are drawn asunder. The less the cell grows after the deposition of the fibre, the more firmly is it attached to its walls. The individual spires of fibres, or particular parts of the spires, often grow together. From these circumstances a very varied configuration of the cell-wall is produced, which may be comprised under two divisions: in the first case, when the fibres are clearly separable, we have *fibrous cells;* and secondly, when the fibres are so grown together that they assume the form of a membrane covered with little dots, we have *pitted cells*, or, as called by Schleiden, *porous cells.* The explanation thus given by Schleiden of the formation of pitted cells cannot be considered as by any means proved to be correct. Others explain such a formation, by supposing a slight enlargement of the primary cell-membrane to take place after the secondary layer has been deposited, by which this is stretched and broken into little holes or slits at various points. The regular distribution however of these holes or slits, combined with the circumstance that each successive layer, as it is deposited, corresponds exactly with the preceding, seem clearly to indicate that such a formation cannot be owing to such mechanical distension alone, but must be regulated by some general law.

Fig. 32.

Fig. 32. Pitted and reticulated cell.

In some cases, as in the Yew (*fig.* 33), in the Mezereon, and in the Lime, &c., we find a spiral fibre or fibres developed in addition to the pits, which appearance also must be considered as another proof of their common origin.

Fig. 33.

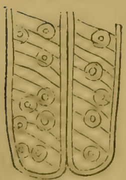


Fig. 33. Wood-cells of the Yew (*Taxus baccata*). After Mohl.

4. Contents of Cells.— Under this head are included nearly all the substances which are formed in the plant, or which have been absorbed by it from the soil. We only propose at present to treat of those contents of cells which are more commonly found, and which have an especial importance at this

stage of our inquiries. The more particular description of many of them will be given under the head of Physiology, or, when treating of the plants which yield them, in Systematic Botany. The detailed account of others, again, belongs to Chemistry, and the applications of Botany to Medicine, the Arts, Domestic Economy, and Manufactures. By some authors the term *endochrome* is used to indicate the whole contents of the cell; it is chiefly employed in describing the Algæ. We shall first describe certain contents which are present more particularly in young cells, and which are actively concerned in their origin and development, as well as in the formation of other substances afterwards contained in them. These are the *Protoplasm*, *Primordial Utricle*, and *Nucleus*. These commonly disappear when the secondary layers begin to be deposited on the walls of the cell.

Protoplasm.—This substance, which is abundant in all young cells, is a white or yellowish, opaque, viscid fluid, either perfectly smooth, or of a more or less granular nature. It may be always detected by the application of sugar and sulphuric acid, when it assumes a pink or rose colour. It should be noticed, however, that this colour is frequently not developed for some minutes. Iodine colours it yellow or brown. It is coagulated by acids and alcohol. It contains nitrogen as an essential ingredient, in addition to the three elements—carbon, oxygen, and hydrogen, of which we have seen the primary cell-membrane is alone composed. The protoplasm is called by some German writers "schleim," and in some English works "mucus," or "mucilage."

Primordial Utricle.—When a cell containing protoplasm is placed in water, or allowed to remain for some time in alcohol, or is exposed to the action of iodine, the contents separate from the wall (*fig.* 34), and are then seen to be bounded by a more or less defined portion of protoplasm having the appearance of a membrane, and which by its contraction has removed all the other contents of the cell from its surface. Mohl, who first discovered this structure, and who believed it to possess all the appearances of an inner cell lining the outer one, called it the *Primordial Utricle*, because this so-called membrane exists previous to the cell-wall formed of cellulose. Whether such an appearance, as that just described, can be considered as owing to the presence of a distinct membrane having the characters of an inner cell, as thus supposed by Mohl; or whether it should not be rather considered as a thin film caused by the coagulation of the surface of the protoplasm by the action

Fig. 34.

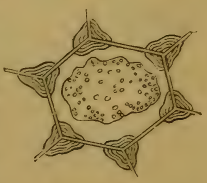


Fig. 34. Cell of the leaf of *Jungermannia Taylori.* After Mohl.

of the reagents applied, is by no means clear, for when a cell containing protoplasm is examined without the aid of reagents, no membrane thus bounding the contents of the cell can be clearly distinguished; indeed, it would appear far more probable that this so-called primordial utricle is merely a thickened layer of the protoplasm lining the cellulose-wall, which assumes the character of a true membrane under the action of reagents, just in the same way as any thickened gelatinous matter, when exposed to the air, would become invested as it dried up by a more or less evident pellicle. This thickened layer of protoplasm or primordial utricle, performs, as we shall afterwards find, a very important part in the process of cell-development; it may be, therefore, always observed in young and vitally active cells. Its existence is in most cases but transitory, disappearing when the secondary layers are being deposited. It is, however, a permanent formation in cells containing chlorophyll (the green colouring matter of plants), as, for instance, in the cells of leaves, and in many of the lower kinds of plants.

Nucleus or Cytoblast.—Almost all young cells contain one or more bodies called *Nuclei* or *Cytoblasts*, which are always in intimate connection with the Primordial Utricle. In the cells of the higher classes of plants the nucleus consists of a rounded or lenticular granular-looking body (*figs.* 8 and 35) generally more transparent than the protoplasm in which it is placed, and containing almost invariably in its interior, one or more usually sharply defined bright points called *Nucleoli.* The nucleoli vary somewhat in their appearance; more commonly they seem to be formed of solid transparent granules, while in other cases they appear like small cavities in the interior of the nucleus. The nucleus and the nucleolus are best observed under the action of iodine, which colours them yellow or brownish. The size of the nucleus in proportion to the cavity of the cell varies greatly; in the very young cells of newly formed parts the nuclei occupy nearly, or entirely, the whole cavity; while in the cells of other parts they are of but small size in proportion to the cavities.

Fig. 35.

Fig. 35. Cell with nucleus and nucleolus.

There are two theories as to the nature of nuclei; by most observers they are considered to be solid granular structures as described above; while Nägeli and others regard them as vesicles.

The above remarks as to the appearance and nature of nuclei apply more especially to those found in the cells of the higher plants. In those of the lower plants they are frequently very

obscure, and, according to Henfrey, the term nucleus is here very loosely applied to irregular granular structures which do not represent the nuclei of Flowering Plants.

The nuclei originate in two ways; either as new formations by the aggregation of granules of protoplasm, or by the division of existing nuclei into two or more separate ones. (See Cell-development, page 59.)

As cells increase in age the nuclei either disappear, or persist as long as the cells retain their vitality; or in some cases they appear to be converted into chlorophyll or starch granules.

The supposed functions of these nuclei will be treated of hereafter in speaking of the process of cell-development. Generally we may add that they require further investigation before we can pronounce positively on many points connected with their structure and development.

The substances just described under the names of Protoplasm, Primordial Utricle, and Nucleus, are those which are especially present in very young cells, in which they perform, as will be presently shown, very important functions. As the cells increase in age, and when in a mature state, a great variety of other substances are found in them, which have been either formed in the plant, or have been obtained from the soil, or substance upon, or in which the plant grows. It does not enter into our purpose at present to describe all these contents, but only a few of the more important. They are all dissolved, or float in a watery liquid, which is commonly called sap.

Sap.—This liquid may be first observed in small vacuoles existing in the protoplasm, and it then constitutes but a small portion of the cell contents; as the cells become mature, the quantity of sap continues to increase, until it ultimately fills their cavities. The amount will necessarily vary according to the conditions under which the plant is placed, especially as regards the amount of water it can absorb or exhale; but as a rule, with but few exceptions, it cannot altogether disappear from the cells of the different organs of the higher plants without destroying the life of those organs. Many of the lower kinds of plants may, however, become completely dried up, but will still retain their vitality.

The sap is in rare cases coloured by substances which are dissolved in it, but commonly it is colourless, and resembles common water. It contains, as we have seen, various substances dissolved or floating in it. Three of these we shall now describe, namely, Chlorophyll, Starch, and Raphides.

Chlorophyll.—This name is applied to the green colouring matter of plants. It is especially abundant in the cells which are situated just beneath the surface of leaves. It occurs either as an amorphous substance, or far more generally under

the form of granules or globules, which float in the cell-sap, or are more or less adherent to the walls of the cell (*fig.* 46).

The nature of chlorophyll is by no means well ascertained. Some observers describe the granules as consisting of soft mucilaginous solid matters; while others describe them as small vesicles containing a green liquid. When they are acted upon by alcohol or ether they retain their form and size but lose their green colour, hence it is clear that they consist of a substance which is coloured green by the presence of colouring matter diffused through them which is soluble in alcohol or ether. The granules when thus freed from green colouring matter are coloured yellow by iodine, and therefore contain nitrogen. It would seem probable from this, as well as from their common occurrence around the starch granules (which, as we shall find in speaking of starch, are developed from protoplasm), that they are simply granules of protoplasm coloured by a green colouring matter to which the name of chlorophyll properly applies. This chlorophyll or green colouring matter is a complex substance, consisting, according to Mulder, of wax, and a matter resembling indigo. An incomplete analysis gives its composition $C_{18}\ H_{18}\ N_2\ O_8$. Chlorophyll is only formed under the influence of light, it never occurs therefore in structures removed from that agent, but exclusively on the parts of plants near the surface. In the autumn it undergoes certain changes which are not well understood, by which it loses its green colour, and assumes various shades of red or yellow.

All the colouring matters contained in the cells which are not green, and to which the peculiar tints of the petals and other parts are due, are frequently comprised under the common name of *chromule*. These are of various natures, and will be treated of hereafter when speaking of the cause of colour in plants.

Starch. — There is no substance contained in the cells which has given rise to more discussion as to its origin and nature than starch. It is, with the exception of protoplasm, the most abundant and universally distributed of all the cell-contents, occurring as it does, more or less, in all parenchymatous cells (*fig.* 36), except those of the epidermis. It is, however, most abundant in the matured structures of a plant, as in the pith of stems, seeds, roots, and other internal and subterranean organs which are removed from the influence of light. In these respects it presents a marked contrast to chlorophyll, which occurs only in young and vitally active structures, which are placed near the surface of

Fig. 36.

Fig. 36. Cell of the Potato containing starch-granules.

plants, and directly exposed to light. When starch occurs in the active vegetating parts, it is then commonly invested by chlorophyll granules.

Starch is not only widely distributed through the different parts of a plant, but it also occurs in varying quantity in probably all classes of plants, except the Fungi. Arrow-root (*fig.* 37), tapioca, sago (*fig.* 38), tous-les-mois (*fig.* 39), and potato starch (*fig.* 40) may be mentioned as familiar examples of starches derived from different plants. In all cases starch is a transitory product stored up for future use, resembling in this respect the fat of animals. When thus required for the nutrition of the plant, it is converted previously, as will be afterwards seen, into dextrine and sugar, which are soluble substances, and can be at once applied to the purposes of nutrition, which is not the case with starch in its unaltered condition, as that is insoluble.

Fig 37. *Fig.* 38.

Fig. 37. West-India Arrow-root.——*Fig.* 38. Sago meal. Both magnified 250 diameters.

Fig. 39. *Fig.* 40.

Fig. 39. Tous-les-mois.——*Fig.* 40. Potato starch. Both magnified 250 diameters.

Starch is composed chemically of carbon and the elements of water. Its exact composition, according to Payen, being $C_{12} H_{10} O_{10}$; the same as cellulose, with which it is therefore isomeric. Starch, however, never occurs naturally in a perfectly pure condition, but it always contains a certain proportion of the peculiar secretions of the plant from whence it is derived. These impurities can never under ordinary circumstances be entirely removed, and hence arises the difference in the value of the various starches used for food and other purposes. Starch is insoluble in cold water, alcohol, ether, or oils. By the action of boiling water it swells up and forms a gelatinous mass. Iodine when applied to it gives a blue colour or some shade of

violet, the distinguishing character of starch and some other matters closely allied to it, as cellulose and amyloid; which latter is a substance found occasionally in the secondary deposits in the albumen of some seeds. The blue color is at once destroyed by the application of heat and alkalies. If starch be exposed to heat for a prolonged period, it is converted into a soluble gummy substance, called *dextrine* or British gum. A similar change is produced in starch by the action of diluted sulphuric acid, and diastase, a peculiar nitrogenous substance occurring in germinating seeds. Starch was formerly considered as peculiar to plants, and its presence therefore was regarded as an absolute distinctive mark between them and animals. Of late years however, a substance presenting the chemical reactions and general appearance of starch has been found in some animal tissues. Such a distinctive character, therefore, can be no longer absolutely depended upon.

Starch has been described as occurring in two states, either in an amorphous condition, or in the form of distinctly defined granules. Its existence in an amorphous state has been described by Schleiden as found in the bark of the *Jamaica Sarsaparilla*, in the seeds of *Cardamomum minus*, and in the underground stem of *Carex arenaria*. The existence of starch in this amorphous condition is, however, by no means clearly ascertained. Starch commonly occurs in the form of colourless transparent granules, varying in size ; which are either distinct from each other as is generally the case (*fig.* 36), or more or less combined so as to form compound granules (*fig.* 41). When fully formed it is usually found floating in the cell-sap, but in a young state it is attached at one point of its surface to the protoplasm or primordial utricle, from which structures, as will be presently seen, it is believed to be developed. In form the granules are always spherical or nearly so in their earliest condition. In some cases this form is nearly maintained in their mature state, as in wheat starch (*fig.* 42); but they frequently assume other forms, as ovate, elliptical, more or less irregular, club-shaped, or angular (see figures). Such arise from the unequal development of the sides of the granules, or from mutual pressure, the same causes indeed which give rise in a great measure to the varying forms of the cells in which they are contained. Starch granules vary also extremely in size in different plants, and even in the same cell. The largest granules known appear to be those of the Potato (*fig.* 40), and Canna starch, or, as it is commonly termed, "Tous-les-mois," where they are sometimes as much as the $\frac{1}{300}$ of an inch in length (*fig.* 39) ; while the smallest granules, among which may be mentioned those of Rice starch (*fig.* 43), are sometimes too small to be accurately measured, being frequently under $\frac{1}{3000}$ of an inch in length.

Fig. 41.

Fig. 42.

Fig. 43.

Fig. 41. Compound starch granules of West-India Arrow-root. After Schleiden.——*Fig.* 42. Wheat starch: magnified 250 diameters.——*Fig.* 43. Rice starch: magnified 250 diameters.

Starch granules, when fully formed, usually present a small rounded spot, which is commonly situated at one end, and which represents the original nucleus upon which after-development has taken place; this is called the *hilum* or *nucleus*. Surrounding this spot a number of fine lines may be also commonly observed, which completely encircle it so as to present the appearance of a succession of irregular concentric shells placed around a common point. The cause of these appearances has given rise to much discussion, and cannot be said even at present, to be completely understood. By some observers, as Nägeli, Martin, and Busk, the starch granule is supposed to be a cell, having a wall of a different nature to that of its contents; the appearance of the concentric striæ being then supposed to be due, either to successive layers of deposit in its interior, the boundaries being thus visible as concentric lines, as is supposed by Nägeli; or to the inrolling or involution of the starch cell, as maintained by Martin; or to the doubling inwards of the wall, so as to form rugæ or folds, as believed by Busk. By those who thus maintain the cellular nature of the starch granule, the nucleus or hilum is supposed to be a cavity in the cell, or a pore or funnel-shaped aperture leading into it. The more commonly received opinion as to the structure of the starch granule, and that which seems to me to be the correct one, is as follows: — the starch granule appears originally in the form of a minute rounded body, which constitutes the *nucleus* or *hilum;* whether this be solid or hollow cannot be positively stated:—around this nucleus, as a starting-point, there is deposited in the course of growth a succession of concentric shells or layers of a like nature as regards their chemical composition, but varying in the amount of water they contain, the outermost being harder, firmer, and containing less water than those in the interior, which are nearer to the nucleus, from which all growth commences. That the different layers of the starch granule vary in density may be at once proved

by the action of polarised light, when each granule usually exhibits a black cross. Those who adopt this view of the structure of the starch granule explain the appearance it commonly presents thus; the rounded spot or hilum being the nucleus of growth, and the concentric lines representing the boundaries of the successive layers of deposit.

Starch granules vary very much in the distinctness and general appearance of their concentric lines, in the same way as they differ exceedingly in form and size when obtained from different sources: those, however, which are obtained from the same plant are more or less uniform in appearance, so that we may distinguish under the microscope the different kinds of starch and refer them to the particular plants from which they have been derived.

With regard to the origin of the starch granules, little was known until recently; but now however, by the researches of Crüger it would appear that they are secreted on the inner surface of cavities or *vacuoles* formed in the general protoplasm of the cell, in the same way as the primordial utricle or superficial pellicle of the protoplasm secretes cellulose on its outer surface (page 56). Hence we find a ready explanation of a circumstance already noticed when treating of chlorophyll, namely, the common occurrence of starch granules imbedded in that substance; for chlorophyll, as we have seen, is probably nothing more than portions of protoplasm containing a substance coloured green under the action of light, so that starch granules may as readily be formed in cavities of this coloured protoplasm as in that of any other.

Raphides.— This name is now commonly applied to crystals of any form found in the cells of plants, although the term *raphides* (which is the Greek for needles) was originally given to those only which were shaped like a needle (*fig.* 46). They may be found more or less in all classes of plants, and in all their organs; generally, however, they are most abundant in the stems of herbaceous plants, in the bark of woody plants, and in leaves and roots. Although they are commonly described as occurring only in the cells, they are sometimes found in the vessels also, which are however, formed of rows of cells, as will be hereafter noticed, and in intercellular cavities; the occurrence of crystals, however, in the latter position is probably accidental. In some plants they occur in such enormous quantities that they exceed in weight the dried tissue in which they are deposited; this may be especially observed in some Cactaceæ; thus Edwin Quekett found in the stem of the Old-man Cactus (*Cereus senilis*) as much as 80 per cent of crystals in the dried tissue. Professor Bailey also found in a square inch of Locust-bark of the thickness of ordinary writing-paper, more than a million and a half

of these crystals. The root of Turkey or Russian rhubarb commonly contains from 35 to 40 per cent, hence when chewed it appears very gritty; and, as this kind of rhubarb contains commonly a larger proportion of raphides than any other, this grittiness has been employed as a means of distinguishing it from them. The raphides are commonly contained in cells, in which starch, chlorophyll, and other granular structures are absent, although this is by no means necessarily the case.

The raphides occur either singly in the cells in which they are found, as in the inner bark of the Locust-tree (*fig.* 44); or far more commonly there are a number of crystals in the same cell, in which case they are usually arranged in one of two ways, that is — either placed side by side as in the stem of Rumex (*fig.* 46); or in groups radiating from a common point, and forming a clustered or conglomerate appearance,

Fig. 44.

Fig. 45.

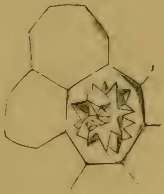


Fig. 46.

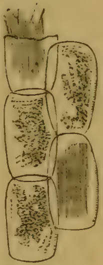
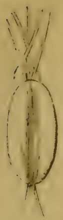


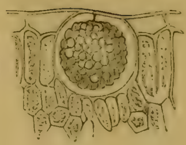
Fig. 44. Raphides in the cells of the inner bark of the Locust tree. After Gray.——*Fig.* 45. Conglomerate raphides.——*Fig.* 46. Acicular raphides. Two cells contain raphides, and three of them chlorophyll.

as in the cells of the stem of the common Beet (*fig.* 45). In the common Arum and some other Araceæ, the cells which contain the raphides are filled with a thickened sap, so that when they are moistened with water, endosmose takes place, which distends them and causes them ultimately to burst and discharge their crystals from an orifice at each end (*fig.* 47). Such cells have been called *Biforines*

In many plants belonging to the families of the Urticaceæ, the Moraceæ, and Acanthaceæ, there may be frequently observed situated generally just beneath the surfaces of the leaves, or sometimes more deeply, peculiar crystalline structures, to which the name of *Cystolithes* has been applied by Weddell. They constitute the *gummi keulen* of Meyen. These consist of an enlarged cell containing commonly a globular or club-shaped mass of crystals (*figs.* 48 and 49.) suspended from the top

Fig. 47. *Fig.* 48. *Fig.* 49.





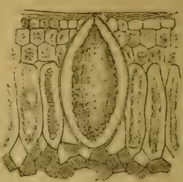


Fig. 47. **Raphides of an Arum being discharged under the influence of water.——*Fig.* 48. Cystolithe, from *Parietaria officinalis*. After Henfrey. ——*Fig.* 49. Cystolithe from the leaf of *Ficus elastica*. After Henfrey.**

by a kind of stalk formed of cellulose, upon which the crystals are deposited as upon a nucleus. The crystals are also found of other shapes besides the globular and clavate in these Cystolithes. They always consist of oxalate of lime.

The raphides appear to be simple chemical combinations of the organic and inorganic acids and bases (commonly lime) which are contained in the fluids of the plant. Such crystals, therefore, vary in composition, those of most frequent occurrence consist of oxalate of lime, as in Rhubarb root. The acicular raphides are also said by some observers to be composed of oxalate of lime, while others state them to be phosphate of lime; their composition may possibly vary in different plants. Carbonate of lime crystals also frequently occur in plants, as in many of the Cactaceæ. Crystals of tartrate of lime are found in the old stems of some Cactaceæ; those of sulphate of lime in the Musaceæ; and those of other composition occasionally occur.

Raphides, as might be supposed from their varying composition, assume different crystalline forms. Some are acicular or needle-shaped, (as we have already seen,) with pyramidal ends; others, as those of oxalate of lime, crystallize in octahedra and in right-angled four-sided prisms. Carbonate of lime crystals assume a number of forms, but most commonly that of the rhombohedron. Other crystals with a different composition assume a variety of forms, which it is not necessary for us to allude to.

Section 2. Of the Kinds of Cells and their Connexion with each other.

We have already seen that when cells are of such forms that combined together they merely come in contact without

perceptibly overlapping, they are called *parenchymatous*; but that when pointed at their ends, so that in combination they overlap each other, they are termed *prosenchymatous*. We have also seen that such extreme forms are connected by all sorts of transitional ones. Formerly, all elongated organs found in plants were supposed to have an entirely distinct origin from the cells, and were described under the names of Woody Fibres, and Vessels or Ducts, but it is now known that they are all derived originally from ordinary cells, and owe their peculiar appearances, either to various modifications in shape, which the latter undergo in the course of growth, or to their combination and union with each other. This common origin of the Woody Fibres of old authors and the Vessels or Ducts, with the cells, is proved by the fact, that gradual transitional forms from the one to the other may be commonly observed; and also by tracing their development, when it will be found that all these organs, however modified in shape and appearance, are derived originally from the ordinary cell. All the observations made previously, therefore, as to the chemical and general properties of cell-membrane, as well as to the mode of growth and deposition of secondary layers, apply equally to the Vessels or Ducts. We have already stated this to be the case with regard to the Woody Fibres, which we have spoken of under the name of Wood-cells. By the combination of the different kinds of cells, we have various compound structures formed which are called Tissues, these we now proceed to describe. The most important and the most abundant of them all is

1. Parenchyma.—This, which may be considered as the typical form of cellular tissue, is composed of comparatively thin-walled cells, whose length does not exceed their breadth, or in which the proportion of the two diameters does not vary to any remarkable extent. Parenchyma has been divided in various ways by authors, the divisions being founded upon the forms of the component cells, their modes of cohesion, and other peculiarities. It will be sufficient for our purpose to adopt the simple arrangement of Schleiden, which is as follows:—

1. *Incomplete Parenchyma* is that in which the component cells are in contact only at a few points, so that numerous interspaces are left between their sides; of this there are two varieties.

a. *Round or elliptical Parenchyma.* (*Fig.* 50.)—This is formed of rounded or more or less oval cells, and commonly occurs in succulent plants, and in those parts where the tissues are of a lax nature, as in the pulpy portions of leaves and fruits. The name of *merenchyma* is frequently applied by authors to this form of parenchyma. It is connected by various transitional forms with

b. *Spongiform Parenchyma*, which consists of stellate cells (*fig.* 51), or of cells with an irregular outline produced by projecting rays, and in contact only by the extremities of such rays, so as to leave large irregular spaces between them. This occurs commonly in the tissue at the under surface of most leaves (*fig.* 80, *c*), and frequently in the air-passages of plants.

Fig. 50.

Fig. 50.
Round or elliptical parenchyma.

Fig. 51.
Spongiform or stellate parenchyma, composed of stellate cells with three-cornered intercellular spaces.

Fig. 51.

2. *Complete Parenchyma.*— This includes all those forms which are composed of cells in perfect contact on all sides, so that no interspaces are left between them. Of this there are three varieties.

a. *Regular Parenchyma.*—This is formed of dodecahedral or polyhedral cells, the faces of which are nearly equal. It commonly occurs in the pith of plants (*figs.* 4 and 5).

b. *Elongated Parenchyma*, composed of cells elongated in a longitudinal direction so as to become cylindrical, or prismatic, occurring frequently in the cellular tissue of Monocotyledonous Plants (*fig.* 9).

c. *Tabular Parenchyma*, consisting of tabular cells. It is found in the epidermis and other external parts of plants (*figs.* 80 and 81). A variety of this kind of parenchyma is called *muriform*, because the cells of which it is composed resemble in their form and arrangement the courses of bricks in a wall (*fig.* 52). This variety occurs in the medullary rays of wood, or, as they are commonly called, the silver grain (see page 83).

Fig. 52.

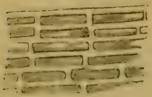


Fig. 52.
Muriform parenchyma.

Such are the commoner varieties of parenchyma, all of which are connected in various ways by transitional forms, which it is unnecessary to describe here. When ordinary parenchymatous cells become much thickened by soft secondary deposits, as in the fronds of many Algæ, &c., the tissue formed by them is called by some authors *collenchyma*; or if the secondary deposits are of bony hardness, as in the stones of fruits, &c., Henfrey has proposed the term *sterenchyma*.

It frequently happens that ordinary parenchymatous cells become thickened by secondary deposits, in such a manner as

to form *pitted cells*, or some variety of *fibrous cells.* The combination of these so as to form tissues, constitutes respectively, *Pitted Cellular Tissue*, and *Fibro-cellular Tissue.* These tissues are, however, but slight modifications of true parenchyma, and are frequently included by authors with the other varieties under that name.

In some of the lower orders of plants there is a kind of tissue present, which is quite as distinct from parenchyma, as this is from prosenchyma and the tissues formed by the vessels of plants. To this the names of *Tela contexta* and *Interlacing fibrilliform Tissue* have been given. It occurs especially in Fungi and in Lichens (*fig.* 10), and consists of very long thread-like cells, or strings of cells, simple or branched, with either thin, soft, readily destructible walls, as in Fungi, or dry and firm ones as in Lichens, the whole inextricably interwoven or entangled with each other, so as to form a loose fibrilliform tissue.

The tissues above described constitute the entire structure of the lower orders of plants, as the Algæ, Fungi, and Lichens, which are hence frequently termed Cellular Plants; while those orders above them, which contain commonly, in addition to cells, vessels and prosenchymatous wood-cells, are called Vascular Plants. In these higher orders of plants, parenchymatous cells constitute all the soft and pulpy parts; and in cultivating plants or parts of plants for culinary purposes and for food generally, the great object aimed at is to develope this kind of tissue as much as possible. Parenchyma is connected by various intermediate conditions with *prosenchyma*, which we now proceed to notice.

2. Prosenchyma.—The most perfect form of prosenchyma is that commonly termed *Woody Tissue*, (*Woody Fibre* of the old writers, *Pleurenchyma* of Lindley and Meyen).

Fig. 53. *Fig.* 54. *Fig.* 55.

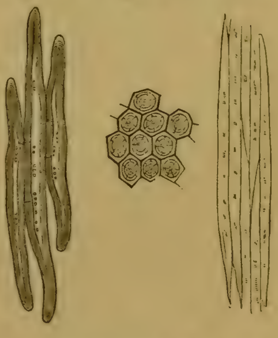


Fig. 53. Prosenchymatous cells.——*Fig.* 54. Horizontal section of prosenchymatous cells.——*Fig.* 55. Prosenchymatous cells in combination.

This tissue consists of very fine cells, elongated and tapering to a fine point at each of their extremities, their inside being much thickened by secondary deposits (*fig.* 53), and when in contact with each other, overlapping by their pointed ends, so that they are firmly compacted together and

leave no interspaces (*fig.* 55). The woody portions of all plants consist in part of this form of tissue. It is also found in the liber or inner bark mixed with parenchyma, and in the veins of leaves and those of other membranous expansions of the stem or its divisions.

We distinguish three kinds of cells which enter into the composition of Woody Tissue; namely, the ordinary *Wood-cells*, the *Disc-bearing* or *Punctated Wood-cells*, and *Liber-cells;* these form respectively, by their combination, the ordinary *Woody Tissue*, the *Disc-bearing* or *Punctated*, and *Woody Tissue of the Liber.*

a. *Woody Tissue.*—This, the ordinary kind of woody tissue, is composed of cells the sides of which, although thickened by secondary layers, either present a homogeneous appearance, as is more commonly the case (*fig.* 55), or are marked with little dots or pits, as in pitted cells. The occurrence of spiral fibres, or rings, or reticulations, is exceedingly rare in wood-cells. The secondary deposits are arranged in concentric layers, which increase in number as the cells progress in age, so that in old wood their cavities are often nearly obliterated (*fig.* 54). This kind of tissue occurs in the wood of most trees, except that of the Coniferæ and allied orders ; and in the veins of leaves, &c. The peculiar manner in which these wood-cells are arranged with respect to each other, overlapping at their pointed extremities, and thus becoming firmly cemented, as it were, together, combined with the thickness of their walls, renders this tissue very strong and tough, and thus admirably adapted for those parts of plants in which it is found, and where such qualities are especially required.

b. *Disc-bearing Woody Tissue.* (*Glandular of Lindley, Punctated of some authors.*)—This tissue is composed of those wood-cells called *Disc-bearing Wood-cells*, which have been already described. (See page 13.) This tissue constitutes generally nearly the whole of the wood of the Coniferæ and allied order Cycadaceæ, as well as a portion of the wood of some other plants, as *Wintera aromatica*, *Illicium floridanum*, &c. The disc-bearing wood-cells, however, in the latter cases, are somewhat modified, the discs being here found without the central pit or dot (*fig.* 24). These disc-bearing wood-cells are much larger than the other kinds, being often as much as $\frac{1}{300}$ or $\frac{1}{200}$ of an inch in diameter, while the latter are frequently not more than $\frac{1}{3000}$, or on an average about $\frac{1}{1500}$ of an inch in diameter.

c. *Woody Tissue of the Liber.* (*Bast Tissue of some authors.*)—This consists of cells much longer than ordinary wood-cells (*fig.* 57), with very thick walls (*fig.* 58), and tougher, but at the same time softer and more flexible. Hence these are a peculiar kind of cells, and have received the distinctive name

of *Liber-cells*, from their common occurrence in the inner bark or liber of stems. This inner bark is also commonly termed *bast* or *bass*, hence the tissue formed by the combination of such cells is called *Bast Tissue.* The liber-cells are sometimes branched (*fig.* 56). Besides the common occurrence of this tissue in the liber, it also occurs as a constituent of the *vascular bundles* of Monocotyledonous stems (see page 72), and also on the outside of many stems in the same class of plants, and in the stems of Mosses. The veins which form the framework of all leaves are also chiefly composed of this kind of tissue. The liber-cells are among the longest that occur in any of the tissues; according to Schleiden, they are frequently four or five inches in length, and in some plants they considerably exceed even this

Fig. 56. *Fig.* 57. *Fig.* 58.

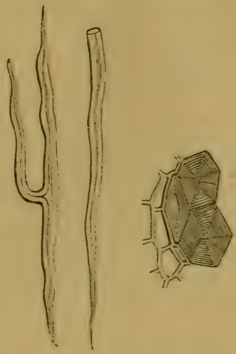


Fig. 56. Upper end of a liber-cell. —— *Fig.* 57. Branched liber-cell. After Schleiden. —— *Fig.* 58. Transverse section of liber-cells, showing the thickness of their walls.

From the peculiar qualities of woody tissue, and especially of the *woody tissue of the liber*, it is admirably adapted for various manufacturing purposes; thus, common Hemp, Flax, New Zealand Flax, Pita Flax, Sunn, Jute, Chinese Grass Fibre, and many others, are all composed of the woody tissue of different plants, and will afford illustrations of those in common use for such purposes. DeCandolle has given the following Table of the relative strength of some kinds of woody fibres as compared with silk, thus :—

Silk supported a weight of	34
New Zealand Flax	$23\frac{4}{5}$
Common Hemp	$16\frac{1}{3}$
Common Flax	$11\frac{3}{4}$
Pita Flax	7

Other fibres brought recently from India are even stronger than the above. While woody tissue is thus shown to possess great strength when used in the form of what are called fibres, these also, when macerated sufficiently, form a pulp from which paper is chiefly manufactured.

All articles manufactured from cotton, which is composed of

long tubular cells placed end to end, with very thin walls, are by no means so strong as those made from woody tissue.

The different kinds of woody tissue are commonly associated in the plant with other organs also of an elongated tubular character, but larger than the prosenchymatous cells of which they are composed. These constitute the

3. Vessels or Vascular Tissue.—These names were originally given from an erroneous idea of their resemblance to the vessels of animals, with which however, they have no analogy. The name of *duct* is also frequently applied to them by authors. By some writers again, a distinction is drawn between a *vessel* and a *duct*, the former term being used to represent a long tubular cell with tapering ends, having spiral deposits in its interior; while the latter is used to indicate an elongated tubular body, which is formed of a row of ordinary cylindrical cells applied end to end, the partitions between the cavities of which have become absorbed so as to form a continuous canal. There are several varieties of vessels or ducts, the nature of which depends upon the modifications which their walls undergo by secondary deposits in their interior. Thus we have *pitted, spiral, annular, reticulated,* and *scalariform ducts,* or vessels as we shall in future call them, as more in accordance with general custom. So long, however, as their nature is remembered, it is of little consequence which term is used.

a. *Pitted or Dotted Vessels.*—These constitute by their combination the *Pitted* or *Porous Tissue* of some authors, or the *Vasiform Tissue, Bothrenchyma,* or *Taphrenchyma* of others; the two latter names being derived from Greek words signifying pits. They either consist of elongated pitted cells with pointed ends (*fig.* 9); or, as is generally the case, of a row of cylindrical pitted cells placed end to end, the intervening partitions of which have become more or less absorbed, so that their cavities form a continuous canal (*figs.* 59 and 60). The origin of pitted vessels from a row of cells of a similar pitted nature, is clearly shown in many instances by the contractions which their sides exhibit at various intervals, by which they acquire a beaded or jointed appearance (*figs.* 59 and 60); for these joints evidently correspond to the points where the component cells come in contact, and in some cases even we find the intervening membrane not completely absorbed between the cavities, but remaining in the form of a network or sieve-like partition (*fig.* 61). In the stems of herbaceous plants we may sometimes succeed in separating these vessels into their component parts, and thus clearly show their origin from cells. Pitted vessels generally terminate obliquely (*fig.* 61), and, when they combine with neighbouring vessels, the oblique extremities of the latter are so placed as accurately to correspond with the former. In some cases, however, where the pitted vessels are pointed at the

ends, they overlap more or less by those points (*fig.* 9). Some-

Fig. 59. *Fig.* 60. *Fig.* 61.

Figs. 59 and 60. Beaded pitted vessels.——*Fig.* 61. Pitted vessel terminating obliquely, and showing that the partition wall by which it was separated from the adjoining vessel has been incompletely absorbed.

times pitted vessels present a branched appearance. They may be commonly found in the wood of Dicotyledons, and generally only in that part of such plants. They are mixed with the ordinary wood-cells, but are much larger than those and the other tissues found there, as may be seen by making a transverse section of the wood of the Oak, Chestnut, and other trees, when the holes then visible to the naked eye are caused by their section (*fig.* 169, *v*). The pitted vessels are generally among the largest occurring in any tissue.

Fig. 62. *Fig.* 63.

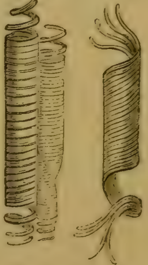


Fig. 62. Simple spiral vessels.——*Fig.* 63. Compound spiral vessels.

b. *Spiral Vessels.*—This name is applied to lengthened cylindrical cells with tapering extremities, having either one continuous spiral fibre running from end to end, as is commonly the case (*fig.* 62), or two or more fibres (*fig.* 63) running parallel to each other. Those with only one spiral fibre are termed *Simple Spiral Vessels;* those with more than one, *Compound Spiral Vessels.* The latter kind are well seen in the stem of the Banana and allied plants, in the young shoots of the Asparagus, and in the Pitcher Plant. The spiral fibres of *Musa textilis*, a plant belonging to the same genus as the Banana and Plantain, are used for the manufacture of delicate muslins in India. The fibre contained within the spiral vessel is generally so elastic as to admit of being un-

coiled when the vessel is pulled asunder, in which case the wall is ruptured between the coils. This may be commonly seen by the naked eye by partially breaking the young shoots or leaf-stalks of almost any plant, or the leaves of the Hyacinth, Banana, and others, and gently pulling asunder the two ends, when the uncoiled fibres appear like a fine cobweb. In most cases the coils of the fibre are close together, so that the primary membrane cannot be observed between them; in other cases, however, they are more or less separated by portions of membrane (*fig.* 62). The latter appearance is probably caused by the growth of the primary membrane after the fibre has been deposited, by which the coils become extended and separated from each other. The fibre is generally turned to the right as in spiral cells, although instances occur in which it is wound in the opposite direction. Balfour says that in the garden Lettuce, spiral vessels are found, some of which have the fibre turned to the right, while in others it turns to the left. When spiral vessels come in contact they overlap more or less at their ends (*fig.* 62), and frequently the membrane between their cavities then becomes absorbed so that they communicate with each other. Spiral vessels sometimes present a branched appearance, which is generally occasioned by the union of separate vessels in a more or less oblique manner (*fig.* 65); or occasionally, it is said, as in the Gourd and some other plants, by a division of the fibres of distinct vessels (*fig.* 64). Spiral vessels occur in the sheath surrounding the pith of the stems of Dicotyledons (*fig.* 171, *d*), in the vascular bundles of Monocotyledons (*fig.* 167, *sv*), and in some of the higher Acotyledons. They also exist in the petiole and veins of leaves, and of all other organs which are modifications of them, as bracts, sepals, petals, &c. They may be also frequently found in roots. In size they vary from the $\frac{1}{300}$ to $\frac{1}{3000}$ of an inch in diameter. The average size is about the $\frac{1}{1000}$. Spiral vessels are sometimes called *Tracheæ* or *Trachenchyma*, from their resemblance to the tracheæ or air-tubes of insects.

Fig. 64.

Fig. 65.

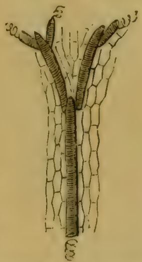


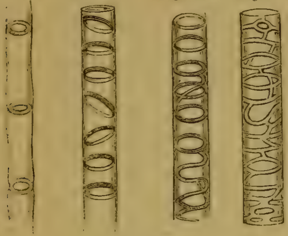
Fig. 64. Branched spiral vessel. *Fig.* 65. Union of spiral vessels in an oblique manner.

Annular, Reticulated, and Scalariform Vessels.—These constitute the spurious tracheæ of some authors.

c. *Annular Vessels.*—These consist of vessels in which the spiral fibre appears in the form of rings (*figs.* 66 and 67). Sometimes the whole of the vessel presents this ringed appearance (*figs.* 66 and 67); while in others, we find two rings connected by

one or more turns of a spiral, the two forms irregularly alternating with each other (*fig.* 68). These vessels are of rarer occurrence than the other modifications of spiral vessels. In size they vary from about $\frac{1}{400}$ to $\frac{1}{800}$ of an inch in diameter. Annular vessels occur especially in the vascular bundles of the stems of soft rapidly growing herbaceous plants among Dicotyledons ; also in those of Monocotyledons ; and in Flowerless Plants. In the latter they exist especially, and of a very regular character in the Equisetaceæ.

Fig. 66. *Fig.* 67. *Fig.* 68. *Fig.* 69. *Fig.* 70. *Fig.* 71.



Figs. 66 and 67. Annular vessels.——*Fig.* 68. Vessel showing a combination of rings and spiral fibre. ——*Fig.* 69. Reticulated vessel.——*Fig.* 70. Prismatic scalariform vessels of a Fern.——*Fig.* 71. Cylindrical scalariform vessels of the Vine.

d. *Reticulated Vessels.*—In these vessels the spiral convolutions are more or less irregular, and connected in various ways by cross or oblique fibres, so as to form a branched or netted appearance (*fig.* 69). These vessels are generally larger than the annular, and of much more frequent occurrence. They are found in similar situations.

e. *Scalariform Vessels.*—These are but slight modifications of the reticulated vessels, and owe their peculiarity to the sides being marked by transverse bars or lines, arranged over one-another like the steps of a ladder, whence their name (*figs.* 70 and 71). It is frequently difficult to determine whether this appearance of lines or bars is caused by the secondary deposits or fibres, or whether it is not owing to the presence of spots which are thinner than the surrounding parts of the wall, as with the pits of pitted vessels. Probably in most instances at least, this is true; while in others, it would appear to be caused by the fibre, as it sometimes happens that scalariform vessels may be unrolled, as is the case with the true spiral vessels. Scalariform vessels thus appear to form an intermediate stage between pitted and spiral structures. These vessels are sometimes cylindrical tubes like the other kinds, as in the Vine (*fig.* 71) and many other Dicotyledonous Plants, in which condition they are apparently

but slight modifications of reticulated vessels; but in their more perfect state, scalariform vessels assume a prismatic form, as in Ferns (*fig.* 70), of which they are then especially characteristic.

The *annular*, *reticulated*, and *scalariform* vessels have commonly tapering points like the true spiral vessels, and thus overlap at their extremities when they come in contact (*fig.* 70), in which case they appear to be nothing more than elongated tubular cells. In some other instances they terminate more or less obliquely, or by flattened ends, as if formed of rows of cells like most pitted vessels, and that this is their real origin in such cases is proved also by the occurrence occasionally of contractions on the sides of their walls, so that they assume a beaded appearance, such contractions indicating the points where the component cells come in contact (*figs.* 66 and 71). In rare instances the true spiral vessels also present similar contractions on their walls.

These vessels are but slight modifications of the true spiral. This is proved by the fact that we frequently find in the same vessel one or more of the above forms combined with the spiral (*figs.* 68 and 72), and thus forming intermediate states of each other. According to Schleiden and others, they are not only slight modifications of spiral vessels, but are actually produced from them in consequence of certain alterations which take place in the course of their development. Thus, annular vessels according to this view, are formed by the growing together of portions of the original spiral fibre into rings, the intermediate portions between such rings becoming ultimately absorbed. Reticulated and scalariform vessels again, are said to be formed by the formation of cross fibres in various directions between the coils of the spiral fibre, so that the spiral is converted into a reticulated or scalariform vessel. Other observers, especially Mohl, state positively that there is no change produced in the condition of the fibre within these vessels by age, but that it is always deposited originally in the same condition which it ultimately assumes, and that the seeming transitional stages from spiral vessels into annular and reticulated, are permanent intermediate forms between them. The first view, that which has been so ably advocated by Schleiden, seems to me to be most in accordance with the position and ordinary appearances presented by them respectively.

Fig. 72.

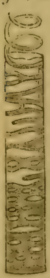


Fig. 72. Vessel showing a combination of spiral and reticulated fibres, and scalariform markings.

f. *Laticiferous Vessels or Tissue.*—These constitute the *Milk-vessels* of the old authors. They consist of long branched tubes

or passages, lying in no definite position with regard to the other tissues (*figs.* 73 and 74), and anastomosing or uniting freely with each other like the veins of animals, from which peculiarity they may be at once distinguished from other vessels. In the pith of the Elder, according to Henfrey, unbranched laticiferous vessels occur. When first formed, their sides are very thin and the vessels are also exceedingly minute, but they become large and thick-sided as they increase in age, but rarely present any pits or spiral deposits in their interior, as is the case in the thickened cells and vessels already described. A common size is the $\frac{1}{1400}$ of an inch in diameter. They derive their name from containing a watery fluid called

Figs. 73 and 74.

Figs. 73 and 74. Laticiferous vessels.

latex, which when exposed to the air becomes milky, and is either white, as in the Dandelion, Spurges, Poppy, India-Rubber, Lettuce, &c.; or coloured, thus yellow latex is well seen in the Celandine. The latex has a number of granules or globules floating in it, which are composed of caoutchouc, or analogous gum-resinous matters, and occasionally, mixed with them may be observed peculiar-shaped starch granules, as in Euphorbia (*fig.* 75). Laticiferous vessels were first discovered by Schultz, who also described the latex as constantly circulating in them, and hence the term Cinenchyma or moving tissue has been applied to them. The movements thus described by Schultz will be alluded to hereafter, when speaking of the physiology of cells. These vessels occur especially in the inner bark of Dicotyledons, in the pith, and in the stalks and veins of leaves. They are also to be found in the vascular bundles of Monocotyledons and all parts which are prolonged from them. In Acotyledons they exist only in the higher orders.

Fig. 75.

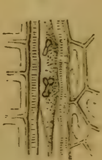


Fig. 75. Latex vessels from a species of Euphorbia; the latex containing starch grains of a peculiar form. From Henfrey.

Their nature or origin is by no means well ascertained. By some vegetable anatomists they are considered to be formed, like the ordinary pitted vessels, from rows of cells arranged in various directions with respect to each other, the partitions between their cavities being more or less absorbed, so that they communicate freely together. Others again, as Mohl and Henfrey, consider them as passages between the cells,

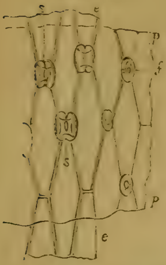
which have originally no proper membrane, but acquire one subsequently by the deposition of matter of varying thickness from the secretions which they contain. More recently again, Schacht has advanced an opinion that they are all *liber-cells.* Further investigation is necessary before we can therefore pronounce positively as to their origin or nature. Our own opinion is, that they vary in their nature in different plants, and in different parts of the same plant. Trécul has lately endeavoured to prove that the laticiferous vessels are in direct connexion with the spiral, but we cannot satisfy ourselves of the truth of this.

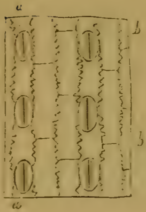
We have now described all the different forms of cells, and the modifications they undergo so as to form vessels. The different kinds of vessels and woody tissue or fibres, are more or less united together, and have always a tendency to develope and arrange themselves in longitudinal or vertical bundles in the parts of the plant where they are found, and thus they may be readily distinguished from the ordinary parenchyma in which they are placed, both in their forms and mode of elongation. We thus find it very convenient to speak of the bundles formed by the combination of the fibres and vessels under the collective name of *Fibro-vascular Tissues*, or the *Fibro-vascular*, or *Vertical*, or *Longitudinal System*, to distinguish them from the ordinary cellular tissue, which constitutes the *Parenchymatous*, or common *Cellular*, or *Horizontal System.*

4. Epidermal Tissue.—In the higher Flowerless, and generally in the Flowering Plants, the cells situated on the surface of the different organs vary in shape and in the nature of their contents from those placed beneath them, and form a firm layer which may commonly be readily separated as a distinct membrane or skin. To this layer the term *Epidermal Tissue* is given. This is generally described as consisting of two parts: namely, of an inner portion called the *Epidermis*, and of an outer thin pellicle to which the name *Cuticle* is given. By Carpenter, however, and some other authors, these terms are used in precisely the reverse sense ; thus Cuticle to indicate the Epidermis, and *vice versa.* We use the term as first mentioned, because more in accordance with general usage, although it must be admitted that the name Epidermis, signifying as it does, a membrane lying upon the dermis or skin, would be more appropriate if applied in the latter sense.

a. *Epidermis.*—This consists of one or more layers of cells, firmly united together by their sides, and forming a continuous membrane, except at the points where it is perforated by the Stomata, presently to be described (*fig.* 91). These cells are generally of a flattened tabular character, the sides of which vary much in their outline ; thus in the epidermis of the *Iris*, and many other Monocotyledons they are elongated hexagons

Fig. 76. *Fig.* 77. *Fig.* 78.





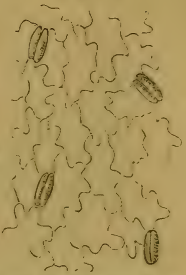


Fig. 76. Epidermal tissue from the leaf of the Iris (*Iris germanica*). *p, p.* Cuticle. *s, s.* Stomata. *e, e.* Epidermal cells. After Jussieu. —— *Fig.* 77. Epidermis of the Maize. *a, a.* Stomata. *b, b.* Zigzag reticulations formed by the sides of the cells. —— *Fig.* 78. Sinuous epidermis with stomata, from the garden Balsam.

(*fig.* 76); in that of the Maize they are zigzag (*fig.* 77); whilst in the Madder, the common Polypody, &c., they are very irregular or sinuous (*fig.* 78); and in the epidermis of other plants we find them square, rhomboid, &c.

Ordinarily in European plants and others the epidermis is formed of but one row of cells (*figs.* 79 and 83), but in tropical plants we frequently find two (*fig.* 80), three, or more, as in the Oleander (*fig.* 81), by which provision that plant is admirably adapted, as will be afterwards explained, for growth in a hot dry climate. The upper walls of the epidermal cells are generally much thickened by layers of secondary deposits, which gradually be-

Fig. 79.

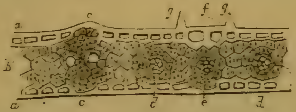


Fig. 79. Vertical section of the leaf of the Maize, showing the epidermis, *a*, formed of one row of cells, with projecting hairs, *g, g*.

come thinner, and terminate on the side walls (*fig.* 82). This thickening of the upper walls of the epidermal cells may be especially observed in leaves of a leathery or hardened texture, as in those of the Oleander (*fig.* 81), Aloes, Hoya (*fig.* 82), Box, Holly, &c., and in the stems of Cactaceæ (*fig.* 83). These thickening layers upon the inner walls of the upper or external surface of the epidermal cells were formerly confounded with the *Cuticle* or thin pellicle which is situated on the outside of the epidermis (*fig.* 82, *a*). Mohl, to whom

Fig. 80.

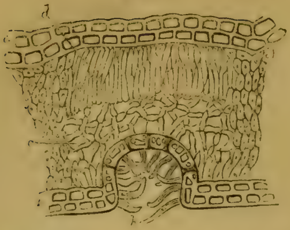


Fig. 81.

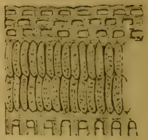


Fig. 80. Section through the leaf of a Banksia. *a, a.* Epidermis with two rows of cells. *c.* Spongiform parenchyma. *b.* Hairs which are contained in little depressions on the under surface of the leaf. After Schleiden.
Fig. 81. Section through the leaf of Oleander, showing the epidermis composed of three layers of thick-sided cells, and placed above a compact parenchyma of vertical cells. After Brongniart.

belongs the merit of first establishing this point, has proposed the name of *cuticular layers of the epidermis* (*fig.* 82, *b*), for these secondary deposits in the epidermal cells.

Fig. 82.

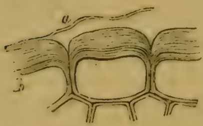


Fig. 83.

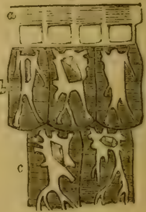


Fig. 82. The epidermis of *Hoya carnosa* treated with caustic alkali. *a.* The cuticle separating: *b.* the swollen, laminated, cuticular layers of the epidermal cells. After Mohl. —— *Fig.* 83. Thickened epidermal cells of a Cactus. After Schleiden.

The cells of the epidermis are always filled with colourless fluids; the green or other colours which leaves and other organs assume is due therefore to colouring matters of various kinds which are situated in the subjacent parenchymatous cells, and which show through the transparent epidermis. In the epidermal cells of many plants, waxy matter is contained; in those of Chara, carbonate of lime; and in those of Equiseta, and the Grasses, silica is met with in such abundance, that, if the organic matter be removed by the agency of heat or acids, a perfect skeleton of the structure will be obtained. These substances are probably deposited in the walls of the cells.

The epidermis covers all parts of those plants upon which it is found which are directly exposed to the air except the stigma, and it is in all cases absent from those which live under water. In the Fungi, Algæ, and Lichens, it is altogether wanting. The young branches of trees are always covered with epidermis, which is replaced at a subsequent period by a layer or layers of cork. The roots of plants are invested by a modified epidermal tissue to which the term *Epiblema* has been given by Schleiden. This consists of cells with thin walls, without stomata, but possessing cellular prolongations externally, called *Hairs*, which will be described hereafter (p. 121). The inner surface of the ovary, the canal of the style, and the stigma of Flowering Plants are also covered by a modified epidermis, resembling epiblema in its general characters, to which the name of *Epithelium* has been given by Schleiden.

b. *Cuticle.*— This consists generally of a thin pellicle, which covers the entire surface of the epidermal cells (*figs.* 82 *a.* and 84), with the exception of the openings called stomata. It forms a sheath also over the hairs. The cuticle has no cellular structure, but is a perfectly homogeneous membrane. It is frequently prolonged into the openings of the stomata, and from thence into the passages which commonly exist between the sides of the cells below the epidermis (*fig.* 86), and may then be separated by boiling in nitric acid as a somewhat funnel-

Fig. 84.

Fig. 84. Cuticle of the Cabbage, showing that it is perforated by the stomata, and forms sheaths over the hairs.

Fig. 85.

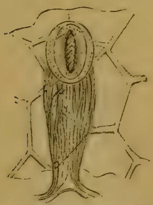


Fig. 86.

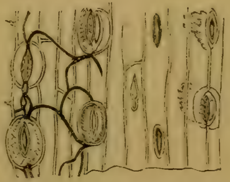


Fig. 85. Cistome from *Cereus peruvianus*. After Gasparrini.——*Fig.* 86. Cistomes of *Ornithogalum nutans*, ramifying in the intercellular passages beneath the epidermis, and becoming connected with one another. After Gasparrini.

shaped bag (*fig.* 85). To this prolongation of the cuticle, which Gasparrini first described, and which he wrongly regarded as a peculiar organ, he gave the name of *Cistome*.

In rare cases, the cuticle, which is generally a very thin pelli-

cle, becomes of considerable thickness, as in the upper surface of the leaves of Cycas, &c. (*fig.* 87). The nature of cuticle has given rise to much discussion, and cannot be said to be as yet accurately determined. By most observers it is regarded as an excretion from the epidermal cells, which has become hardened on their surface; others again, regard the cuticle as the permanent original outer wall of the parent cells of the epidermis, which has become chemically altered by the action of the air. Mitscherlich, again, considers it as a substance analogous to cork, and thus adapted to prevent moisture from penetrating the tissues beneath. We shall refer again to its nature, when speaking of the *Intercellular substance* with which it is supposed to be analogous. A homogeneous membranous layer resembling, if not actually identical with cuticle, is found upon the surface of plants living under water; and upon that of the Algæ, Lichens, and Fungi, which have no true epidermis. The outer membrane of most spores and of pollen grains is of a similar nature to the cuticle, which fact, as argued by Schacht, is a strong evidence of the latter being an excretion from the epidermal cells.

Fig. 87.

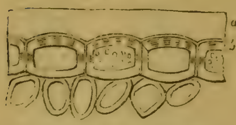


Fig. 87. Section of a leaf of *Cycas revoluta*, showing the epidermis *b*, covered by a thickened cuticle *a*. After Schleiden.

c. *Stomata or Stomates.*—These are orifices situated between some of the epidermal cells, opening into the intercellular cavities beneath, so as to allow a free communication between the internal tissues and the external air (*figs.* 90 and 91, *s*); hence they are also commonly called *breathing pores.* These orifices are surrounded by cells of a different form from those of the epidermis, and which usually contain some chlorophyll granules. There are generally but two cells surrounding the orifice,

Fig. 88.

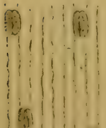


Fig. 89.

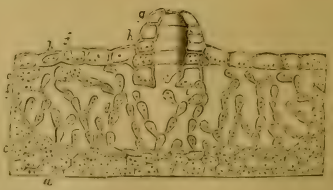


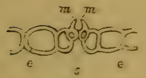
Fig. 88. Epidermis of the Lily, with stomata. —— *Fig.* 89. Stoma of *Marchantia polymorpha* (Hepaticaceæ). After Carpenter.

which are commonly of a more or less semilunar form (*figs.* 76 and 88), so that the whole has some faint resemblance to the

lips and mouth of an animal, and hence the name Stomata applied to such orifices (στόμα, a mouth). The bordering cells of the orifice have been called "stomatal cells," or "pore cells," or "guard-cells," and have the power of opening or closing the orifice which they guard according to circumstances, as will be explained when treating of the functions of stomata. Instead of two stomatal cells, we sometimes, although but rarely, find four, or even more; thus, in some of the Liverworts (*Hepaticaceæ*), the stomata are rounded apertures between the epidermal cells, surrounded by three or more tiers of stomatal cells, each tier being itself composed of four or five cells, the whole forming a kind of funnel or chimney (*fig.* 89).

Upon making a vertical section through the stomata, we find generally that the stomatal cells are placed nearly or quite on a level with those of the epidermis. In other cases, however, and especially when situated upon leaves of a leathery or hardened texture, the stomatal cells are below the epidermal ones, while in some rare instances again they are above them (*fig.* 89). The stomata vary in form and position in different plants and in different parts of the same plant, but they are always the

Fig. 90.



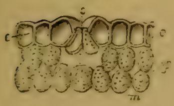


Fig. 91.

Fig. 92.

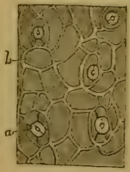


Fig. 93.

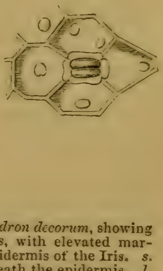


Fig. 90. Vertical section of the epidermis of *Leucadendron decorum*, showing *e, e*, the epidermal cells, with the stomatal cells, *s*, with elevated margins, *m, m.* —— *Fig.* 91. Vertical section of the epidermis of the Iris. *s.* The stomate. *e.* Epidermis. *p.* Parenchyma beneath the epidermis. *l.* Intercellular space into which the stomate opens. —— *Fig.* 92. Epidermis of *Rumex Acetosa*, with rounded stomata, *a.* —— *Fig.* 93. Square stomate of *Yucca gloriosa.*

same in any particular part of a plant. The most common form is the oval (*figs.* 76, 77, and 88); in other instances they are round (*fig.* 92, *a*) or square (*fig.* 93). They are either placed singly upon the epidermis, at regular (*fig.* 76), or irregular intervals (*fig.* 92), or in clusters, the intervening epidermis having none (*fig.* 94). In the Oleander (*Nerium Oleander*) we find little pits beneath the epidermis of the under surface of the leaves which contain a number of hairs, and very small stomata on their sides (*fig.* 95).

Fig. 94.

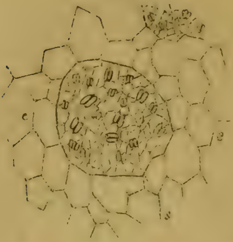


Fig. 95.

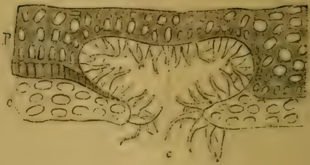


Fig. 94. Epidermis of the leaf of a species of Saxifrage, showing clustered stomata, *s*, with intervening spaces, *c, c*, in which they are absent.—— *Fig.* 95. Vertical section of the leaf of Oleander. *c.* Cavity filled with hairs, with stomata at their sides. *p.* Parenchyma. *e.* Epidermis.

The number of stomata also varies considerably. The following Table will give some idea of their abundance in the leaves.

Stomata in one square inch of surface.

	Upper surface.	Lower surface.
Mezereon	none	4,000
Pæony	none	13,790
Vine	none	13,600
Olive	none	57,600
Holly	none	63,600
Laurustinus	none	90,000
Cherry-Laurel	none	90,000
Lilac	none	160,000
Mistletoe	200	200
Tradescantia	2,000	2,000
House-Leek	10,710	6,000
Garden Flag	11,572	11,572
Aloe	25,000	20,000
Yucca	40,000	40,000
Clove-Pink	38,500	38,500

Stomata are not found upon all plants. Thus they are absent from the lower orders of Flowerless Plants, as the Algæ, Fungi, and Lichens. In the higher orders of such plants they abound, as in Ferns and their allies, while in Liverworts and Mosses they appear to be confined to certain organs. They exist more or less upon all Flowering Plants and their organs. They are, however, far more abundant upon those which are green, thus occurring especially upon leaves as we have seen, and particularly on the under surface of those organs (see Table). On floating leaves, however, we find them only

on the upper surface. They occur also on the young green shoots of plants and on the parts of the flower, and in the interior of the fruit of the Wall-flower, and on the seed of the *walnut.* In such plants as have no true leaves, as the Cactaceæ, they abound upon the green succulent stems. They are commonly only found on those parts which are furnished with a true epidermis, and are accordingly absent in roots and all submersed parts of plants. They are also absent in pale parasitical plants, from the epidermis of plants growing in darkness so as to be blanched, and from the ribs of leaves.

The exact origin and mode of development of stomata is not clearly ascertained. By Mohl, and other authors, the *stomatal cells* are described as originating from one of the cells situated below the epidermis, rising into a space formed by the separation of the epidermal cells at the points where stomata occur. Nägeli, and others again, describe the *stomatal cells* as being formed originally out of true epidermal cells, which are subsequently placed on a level with these, or become pushed downwards or upwards, according to the ultimate position of the stomata We hold the opinion taken by Mohl as to their origin, which we think is proved by the frequent occurrence of chlorophyll in the stomatal cells, such substance not being found in the epidermal cells. While observers differ as to the origin of the stomatal cells, they are all agreed as to their general mode of formation from the particular cells, each constituent cell which forms the stoma becoming divided into two or four stomatal cells, according to the usual mode of cell-division, to be afterwards described (see p. 58); these ultimately separating from each other in the line of partition so as to leave an orifice or interspace between, and thus, accordingly as we have the division of the cells which form the stoma into two or four parts, so we have the orifice bordered by two or four stomatal cells respectively.

5. Appendages of the Epidermis.—Upon the surface of the epidermis, or in the sub-epidermal tissue, there are frequently to be found certain structures consisting of cells variously combined, and containing various substances, which are termed collectively *Appendages of the Epidermis.* We shall treat of these under the two heads of *Hairs* and *Glands.*

1. *Hairs.*—These are thread-like prolongations externally of the epidermal cells and covered by cuticle (*figs.* 79, *g*, and 84). They may either consist of a single cell, when they are called *simple* (*figs.* 96, 97, and 98), or of several cells, when they are called *compound* (*figs.* 103 and 104). Simple hairs may be undivided (*fig.* 96), or forked (*fig.* 97), or branched (*fig.* 98). A very beautiful form of a simple hair is that called Stellate, as seen in *Deutzia scabra*, *Alyssum*, &c. (*fig.* 99); this is formed by a cell dividing horizontally into a number of parts which are arranged in a star-

like form (*fig.* 100). Compound hairs may be also undivided, as is more frequently the case (*figs.* 103 and 104), or branched

Fig. 96. *Fig.* 97. *Fig.* 98.

Fig. 99.

Fig. 100.

Fig. 101. *Fig.* 102.

Fig. 96. Simple unbranched hair of the common Cabbage. —— *Fig.* 97. Forked hair of Whitlow-grass (*Draba*). —— *Figs.* 98 and 99. Branched stellate hairs of Alyssum. —— *Fig.* 100. Stellate hairs from *Althœa officinalis.* —— *Fig.* 101. Branching hair of a species of *Marrubium.* —— *Fig.* 102 Branched hair of *Alternanthera axillaris.* From Henfrey.

(*figs.* 101 and 102). The component cells of such hairs may be also variously arranged, and thus give a variety of forms to them. Commonly the cells of such hairs are placed end to end in a single row, so that they are more or less cylindrical; when the component cells are contracted at the points where they come in contact, they form *moniliform* or *necklace-shaped* hairs (*figs.* 103 and 104). When the cells below are larger than those above, so that they gradually taper upwards to a point, they are *conical*; or when gradually larger from the base to the apex, they are *clavate* or *club-shaped* (*fig.* 105); or when suddenly enlarged at their apex into a rounded head, *capitate* (*fig.* 106); when they are terminated by a hook on one side pointing downwards, they are *uncinate* or *hooked* (*fig.* 107); or if presenting two or more hooks at their apex, they are *glochidiate* or *barbed* (*fig.* 108). Such hairs again, instead of being erect, or more or less oblique upon

the epidermis, may develope horizontally and form a *stellate hair*, as in the Ivy (*fig.* 109), &c.; or two cells may develope in

Fig. 103. *Fig.* 105. *Fig.* 106. *Fig.* 107.

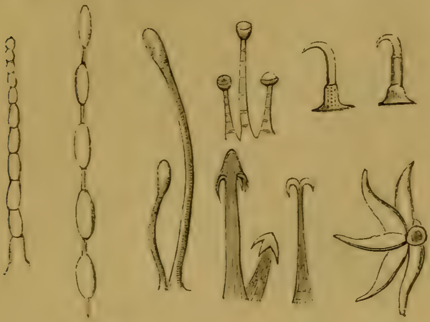


Fig. 104. *Fig.* 108. *Fig.* 109.

Fig. 110.

Fig. 103. Moniliform hair of Virginian spiderwort (*Tradescantia virginica*). —— *Fig.* 104. Moniliform hair of Marvel of Peru (*Mirabilis Jalapa*). —— *Fig.* 105. Clavate hairs. —— *Fig.* 106. Capitate hairs. —— *Fig.* 107. Hooked hairs. —— *Fig.* 108. Glochidiate or barbed hairs. —— *Fig.* 109. Stellate hair from the Ivy. —— *Fig.* 110. Peltate hair from *Malpighia urens*.

opposite directions from another cell raised above the level of the epidermis, by which a *shield-like* or *peltate* hair is formed (*fig.* 110). Besides the above more ordinary forms of hairs, others also occur, which it is unnecessary to mention. Many of the above forms are also found in simple hairs, as well as in compound ones, and the figures are taken indifferently from either. Many hairs have one or more spiral fibres in their interior as those on the seeds of Acanthodium, &c. Such frequently form beautiful microscopic objects (*fig.* 111).

Fig. 111.

Fig. 111. Hairs with spiral fibre in their interior, from the skin of the fruit of *Salvia Horminum*.

When the divisions of a stellate hair are closely connected they form a *scale* or *scurf*, which may be considered therefore as a mere modification of such a hair. A scale may be defined as a flattened, membranous, more or less rounded plate of cellular tissue, attached by its centre, and presenting a more or less irregular margin from

the prolongation of its component cells (*fig.* 112). These scales are particularly abundant on the surface of some plants, to which they communicate a scurfy or silvery appearance, as in the Elæagnus, &c. Such a surface is said to be *lepidote*, from *lepis*, the Greek term for a *scale*. Other modifications of hairs which are allied to the above, are the *ramenta or ramentaceous hairs* so abundant upon Ferns (*fig.* 113). These consist of cells (*fig.* 114) combined so as to form a brownish flattened scale attached by its base to the surface of the epidermis from whence it grows.

Fig. 112.

Fig. 114.

Fig. 113.

Fig. 115.

Fig. 112. Scale or radiating hair of the Oleaster (*Elæagnus*). —— *Fig.* 113. Ramenta from the rachis of a Fern. —— *Fig.* 114. Ramentaceous hair. —— *Fig.* 115. Prickles on Rose-branch.

When the hairs are composed of cells which are short, and have their sides thickened by secondary deposits so that they form stiffened processes, they are then called *setæ* or *bristles*, and the surface is termed *setose* or *setaceous*. These slightly modified,

form *prickles*, which are defined as large hardened processes terminating in a sharp point, and springing from the epidermis or the bark of plants (*fig.* 115). They are especially abundant on the stems of the Rose and Bramble. These must be distinguished from *spines*, to be hereafter described when speaking of branches. (See p. 109.)

Fig. 116.

Fig. 116. *a.* Cotton. *b.* Flax fibres.

The hairs above described commonly contain fluid of a watery nature, which may be colourless or coloured. In other instances they are filled with various special secretions usually of an oily or resinous nature, under which circumstances they are termed *glandular hairs*, and will be again mentioned under the head of *glands*, to which they properly belong. The other kinds of hairs, namely those without secretions, have been called by Lindley and others, *lymphatic hairs*.

Hairs occur upon various parts of plants, and, according to their abundance and nature, they give varying appearances to them, all of which are distinguished in practical botany by special names. The more common position of hairs is upon the leaves and stems, but they also occur on the parts of the flower, the fruit, and the seed. The substance called cowhage or cowitch is the hair covering the legumes of *Mucuna pruriens*, while cotton is the hair covering the seeds of various species of *Gossypium*. Cotton may be readily distinguished under the microscope from the various kinds of liber-cells already described (see page 30), from the circumstance of its component cells collapsing when dry from not possessing any stiff thickening layers, so that it then resembles a flat band, more or less twisted, with thickened edges (*fig.* 116, *a*); while liber-cells from containing thickening material in their interior, always maintain their original cylindrical forms and tapering extremities (*fig.* 116, *b*). On young roots we find cells prolonged beyond the surface which are clearly of the nature of hairs, and have accordingly been termed *radical hairs* (*fig.* 232). The hairs which occur on the parts of the flower frequently serve an indirect part in the process of fertilization, by collecting the pollen or fructifying powder which falls from the stamens; hence such are termed *collecting hairs* (*fig.* 117). A peculiar kind of collecting hair occurs on the style of the Campanulas or hare-bells, the upper part, at the period of fecundation, being retracted within the lower (*fig.* 118). In some cases we find different parts of the plant becoming transformed into hairs. Thus in

the Wig-tree (*Rhus Cotinus*) (*fig.* 119) the flower-stalks become converted into hair-like prolongations, and in many cases, the

Fig. 117. *Fig.* 118. *Fig.* 119.

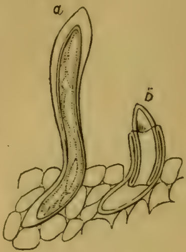


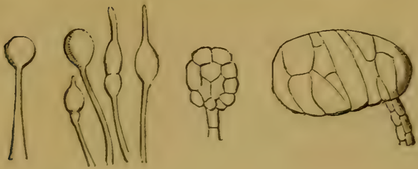
Fig. 117. Pistil of Bell-flower (*Campanula*), with its style covered with collecting hairs.——*Fig.* 118. Magnified representation of two of the collecting hairs of the Bell-flower. *a.* The hair in its normal position. *b.* The hair with the upper part partially drawn within its lower. From Schleiden. ——*Fig.* 119. Flowering branch of the *Rhus Cotinus*, or Wig-tree, with one branch bearing fruit and the others covered with hairs and sterile.

calyx of the *Compositæ* and allied orders, present a hairy character.

2. *Glands.*—This name properly applies only to cells which secrete a peculiar matter, but it is also vaguely given to some other superficial appendages. Glands have been variously divided by different authors: thus by some, into *external* and *internal;* by others, into *simple* and *compound;* while others again, have adopted different classifications. The simplest arrangement, and the one which we shall adopt, is into *external* and *internal* glands.

a. *External Glands.*—These may be again divided into *stalked,* and *sessile* or *not stalked.* The *stalked glands* are those which are commonly called glandular hairs. They are formed of a single cell, dilated at its apex by the peculiar fluid it secretes (*figs.* 120 and 121); or of two (*fig.* 124) or more secreting cells (*fig.* 125) placed at the end of a hair; or they consist of a mass of secreting cells (*figs.* 122 and 123). *Sessile glands* present various appearances, and consist, like the former, of either one secreting cell (*fig.* 127), or of two or more (*fig.* 126). Those with one secreting cell placed above the level of the epidermis are frequently termed *papulæ* or *papillæ.* It is to their presence upon the surface of the ice-plant that the peculiar crystalline appearance of that plant is due. When sessile glands consist of cells containing solid secretions so that

Fig. 120. *Fig.* 121. *Fig.* 122. *Fig.* 123.



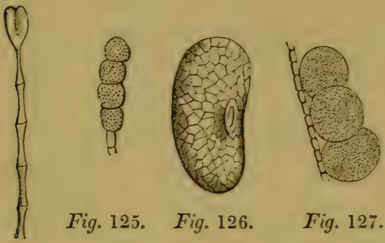


Fig. 124. *Fig.* 125. *Fig.* 126. *Fig.* 127.

Fig. 120. Stalked unicellular gland of Salvia. —— *Fig.* 121. Stalked unicellular glands of Frogsmouth (*Antirrhinum majus*). —— *Fig.* 122. Stalked many-celled gland of *Ailanthus glandulosa*. From Meyen. —— *Fig.* 123. Stalked many-celled gland from *Begonia platanifolia*. From Meyen. —— *Fig.* 124. Many-celled hair of Frogsmouth, terminated by a glandular summit, which consists of two secreting cells. —— *Fig.* 125. Stalked gland with four secreting cells. From Meyen. —— *Fig.* 126. Sessile many-celled gland from the common Hop (*Humulus Lupulus*), commonly termed *lupulinic glands*. —— *Fig.* 127. One-celled sessile glands, termed *papulæ*, or *papillæ*.

they form hardened spherical or other appendages upon the surface of the epidermis, they are termed *verrucæ* or *warts*. When a sessile gland contains an irritating fluid, and is elongated above into one or more hair-like processes, which are placed horizontally (*fig.* 128), or vertically (*fig.* 129), we have a *sting* formed. Stings are sometimes arranged under the head of stalked glands. In the Nettle (*fig.* 129), the sting consists of a single cell, enlarged at its base *b*, by the irritating fluid *f*, which it contains, and tapering upwards to near the apex, when it again expands into a rounded head *s*. The enlarged base is closely invested by a dense layer of epidermal cells, *w e*, which forms a kind of case to it. In touching a nettle lightly, the knob-like head is broken off, and the sharp point of the sting enters the skin, while the irritating fluid is pushed up at the same time into the wound by the pressure thus occasioned, and by the elastic force of the surrounding epidermal cells. If a nettle

instead of being thus touched lightly, be grasped firmly, the sting becomes broken, and as the sharp point does not then enter the skin, no irritation is produced.

Fig. 128.

Fig. 129.

Fig. 128. Sting of a species of Malpighia. *e*. Epidermis. *b*, *b*, *g*. Glandular apparatus.——*Fig.* 129. Sting of the common Nettle (*Urtica dioica*), consisting of a single cell with a bulbous expansion at its base, *b*, and terminated above by a swelling, *s*, and containing a granular irritating fluid, *f*. *we*, Epidermal cells surrounding its base.

b. *Internal Glands.*—These are spaces containing secretions, situated below the epidermis, and surrounded by a compact layer of cells (*figs.* 130 and 131). They are closely allied in their nature to receptacles of secretion (see p. 54); in fact, in many cases, can hardly be distinguished from them, hence it would be probably better altogether to refer them to those organs. In some cases they are of small size, as in the leaves

Fig. 130.

Fig. 131.

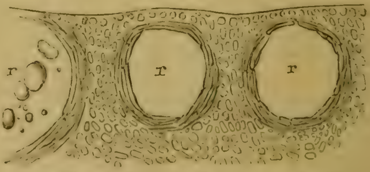


Fig. 130. Gland from the leaf of the common Rue (*Ruta graveolens*). *g*. Gland surrounding a cavity, *l*, and itself surrounded by the epidermis, *c*, and the ordinary cells of the leaf, *wc*.——*Fig.* 131. Internal glands or *cysts* from the rind of an orange.

of the Rue (*fig.* 130), Dittany, Myrtle, Orange, Lemon, St. John's Wort, &c. In such leaves they may be readily observed by holding them up against the light, when they appear as

little transparent spots, which appearance is due to the oily matters they contain refracting the light in a different manner to the parts surrounding them. In some instances they are of large size, and project more or less beyond the surface of the epidermis in the form of little tubercles, as on the rind of the Orange (*fig.* 131), Lemon, Citron, &c. Internal glands are very common in many plants, besides those above mentioned: thus in all the Labiate Plants, as Mint, Marjoram, Thyme, Rosemary, Sage, &c.: and it is to the presence of the secretions they contain that such plants owe their value as articles of domestic economy or as medicinal agents. Lately Brongniart has described what he calls internal glands, in the interior of the ovaries of some Monocotyledons.

Besides the above-described external and internal glands, the true *nectaries* of flowers are also of a glandular nature, and hold a sort of intermediate position between them. They may be termed, therefore, *nectariferous glands*. They are well seen at the base of the coloured leaves of the flowers of the common Buttercup (*fig.* 132) and Crown Imperial (*fig.* 133). These glands consist of a depression into which a honey-like fluid or nectar is secreted by the surrounding cells. The tissue of the stigma of Flowering Plants is also covered by a viscid secretion at certain periods, and may be considered therefore as of a glandular nature.

Fig. 132.

Fig. 133.

Fig. 134.

Fig. 132. Petal of the Ranunculus with a nectary at its base. —— *Fig.* 133. Petal of Crown Imperial (*Fritillaria imperialis*), with a nectariferous gland at its base. —— *Fig.* 134. Lenticels on the branch of a species of Willow.

On the young bark of most plants may be observed little brown, generally oval projections, which have been called *lenticels*, or *lenticular glands* from their supposed glandular nature (*fig.* 134). They have, however, no analogy with glands,

but are merely prolongations externally of the *cellular envelope* of the bark. Their use is altogether unknown, although various functions were ascribed to them at different periods before their structure was properly understood.

6. Intercellular System.—Having now described the different varieties of cells, and the modifications which they undergo when combined so as to form the tissues, we have in the next place to allude to certain cavities, &c., which are placed between their sides. These constitute the *intercellular system.* The cells being, in the greater majority of cases, bounded by rounded surfaces, or more or less irregular outlines, it must necessarily happen that when they come in contact they can only touch at certain points, by which interspaces will be left between them, the size of which will vary, according to the greater or less roundness or irregularity of their surfaces. When such spaces exist as small angular canals running round the edges of the cells and freely communicating with each other, as is especially evident in round or elliptical parenchyma (*fig.* 1), they are called *intercellular passages* or *canals;* but when they are of large size, as in spongiform tissue, *intercellular spaces* (*figs.* 51 and 80, *c*). In most cases these spaces and canals are filled with air, and when they occur in any organ exposed to the atmosphere which possesses stomata, they always communicate with them, by which means a free passage is kept up between the atmosphere and the air they themselves contain. The laticiferous vessels, as we have already seen, appear in many cases at least to be formed out of the intercellular canals. In water plants these intercellular spaces are commonly of large size, and bounded by a number of small cells regularly arranged, by which they are prevented from communicating with each other, or with the external surfaces of the organs in which they occur (*fig.* 135). Such are commonly termed *air-cells* or *cavities.* In these plants they evidently fulfil the important services of enabling them to float, and supplying their interior with air. In other instances we find large air cavities, as in the stems of Grasses, Rushes, Umbelliferous Plants, &c., which appear to have been formed by the destruction of the internal tissue by the more rapid growth of their outer portions. These intercellular canals or spaces frequently act as receptacles for the peculiar secretions of the plant; in which case they are termed *Reservoirs* or *Receptacles of Secretion.* In many cases these are closely allied to the internal glands already described (*figs.* 130 and 131). They vary much in form, but are usually more or less elongated. In

Fig. 135.

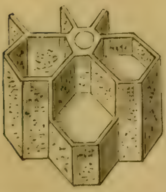
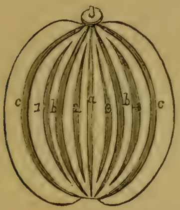


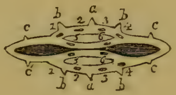
Fig. 135. Air-cells or cavities from the stem of *Limnocharis Plumieri.*

the Coniferæ they contain turpentine, and have therefore been termed *turpentine vessels.* They occur in such plants in the wood, bark, and other parts; those in the wood are elongated tubular passages. In the rind of the fruit of Umbelliferous Plants they form club-shaped receptacles of oil, which are commonly termed *vittæ* (*fig.* 136). These receptacles are

Fig. 136.



a



b

Fig. 136. Fruit of Parsnip (*Pastinaca sativa*). *a*. Dorsal surface. *b*. Horizontal section of the fruit. *a*, *b*, *b*, *c*, *c*. Primary ridges. 1, 2, 3, 4, 5, 6. Vittæ.

found especially in certain orders of plants, to which they communicate important properties.

Intercellular Substance.—The spaces above described as occurring between the sides of cells, appear in some few cases to be filled up by solid matter, to which the name of *intercellular substance* has been given. This appears to be of the nature of cuticle, and in some instances, as we have seen, it is in connexion with that structure through the orifices of the stomata, forming with it the so called *cistome*, (see p. 41). Formerly this intercellular substance was supposed to be universally distributed between the cells glueing them together as it were, and in some plants occurring in great abundance; as in many Algæ, the horny albumen of seeds, between the collenchymatous cells of the common Beet, &c. In these cases the intercellular substance has now been proved to consist really of secondary deposits inside the cells, as may be seen

Fig. 137.

Fig. 138.

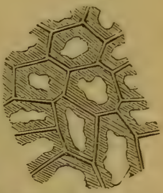


Fig. 137. Section of the albumen of the seed of Betel-Nut Palm (*Areca Catechu*).
Fig. 138. The same, after treatment with sulphuric acid and iodine. After Henfrey.

by any one by the application of iodine and dilute sulphuric acid to such tissues (*figs.* 137 and 138). The existence of this intercellular substance has been even denied altogether, but by far the majority of observers agree as to its presence, to some extent at least, in plants. Further observations are however needed before we can arrive at any definite conclusions respecting it.

Section 3. Formation and Growth of Cells.

The subject of *cell-formation* or *cytogenesis*, has of late years engaged the attention of many able physiologists, by whose united labours we have now arrived at tolerably definite conclusions upon the main points of the inquiry, although many of the subordinate ones are still involved in obscurity. Our limits will not allow of describing in detail all the theories of cell-formation which have been from time to time brought forward by different observers, neither is such necessary, since all are now agreed upon the essential principles of the process; but we shall confine our attention to a general outline of the subject.

Cells can only be formed from a thickened fluid which is contained in the interior of cells, or has been previously elaborated by their agency; hence cells can in no case be formed without the influence of living organisms. The fluid which thus forms the pabulum for the formation of cells, and which must necessarily contain all the materials which ultimately enter into the composition of those cells, has been appropriately termed *protoplasm*, the nature of which we have already fully described. By other observers this formative matter of cells has been variously called *organizable matter*, *vegetable mucilage*, *cytoblastema*, &c.

All cells originate in one of two ways: either free in the cavities of older cells, or at least in the protoplasmic fluid elaborated by their agency; or by the division of such cells. The first is called *Free Cell-formation*, the second *Cell-division*.

1. Free Cell-formation.—We distinguish two modifications of *free cell-formation*. 1. Free cell-formation from a nucleus or cytoblast, and 2. Without the previous formation of a nucleus.

1. *Free Cell-formation from a nucleus*.—This mode was first discovered by Schleiden, who considered it to be the only process of cell-formation occurring in plants. Subsequently he modified his views materially, not only as regarded the manner in which it took place, but also as to its universality, and he now admits that it is only one principal mode of cell-formation. The manner in which it is supposed to take place is as follows (*figs.* 139 and 140):—a portion of the protoplasm collects into a more or less rounded or somewhat oval form, with a defined outer border, thus forming the nucleus of the cell; upon this a layer of protoplasm is deposited, which assumes the form of a membrane, and expands so as to form a vesicle; on the outside of this a cellulose membrane is secreted, and the formation of

the cell is completed. The protoplasmic vesicle in this case forms the subsequent lining of the young cells, and constitutes the "primordial utricle" of Mohl. The ultimate destination of the primordial utricle and the nucleus has been already spoken of in treating of those bodies (see p. 7 et seq.). This process of cell-formation is somewhat differently described by Henfrey thus: "The new cell is formed by a portion of the parent primordial utricle separating itself from the rest of the protoplasm, assuming a globular or oval form, and secreting a cellulose membrane upon its surface, so as to form a new cell, lying free in the cavity of the parent primordial utricle." The antecedent formation of a nucleus is not here alluded to, except the separated portion of the primordial utricle is to be regarded as such; altogether Henfrey appears to consider the nucleus as by no means an

Fig. 139.

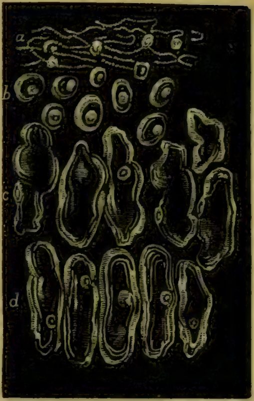


Fig. 139. Cells from the embryo-sac of *Chamædorea Schiedeana* in the act of formation. *a.* The youngest part, consisting of nuclei and protoplasm. *b.* Newly formed cells. *c, d.* Cells still further developed, with nuclei adhering to their sides. After Schleiden.

Fig. 140.

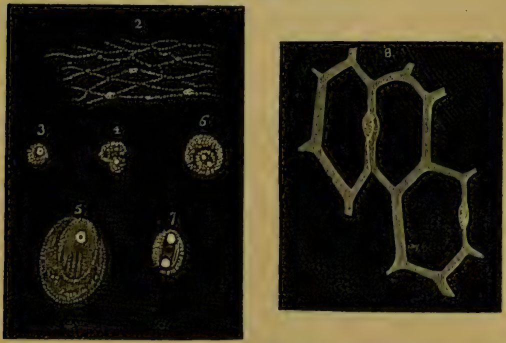


Fig. 140. 2. The part of *fig.* 139, *a*, more highly magnified. 3. A nucleus still more highly magnified. 4. A nucleus with the cell forming upon it. 5. The same more highly magnified. 6. The same: the nucleus here shows two nucleoli. 7. The nucleus of 6, after the destruction of the cell by pressure. 8. The cells of *fig.* 139, *d*, in a higher degree of development, the cell-walls having already united. After Schleiden.

important element in free cell-formation, indeed. if his view of this formation be correct, it appears to me that it can only be regarded as a modification of the process of cell-division. In Flowering Plants free cell-formation only occurs in the embryo-sac, in which part both the germinal vesicles and the cells of the albumen (endosperm) originate according to this method. In the Flowerless Plants it is regarded by some observers, as the mode by which the spores of Lichens, and some of the Algæ and Fungi, originate; by Henfrey and others, however, their formation is believed to be due to a modification of the process of cell-division.

2. *Free Cell-formation without a previous nucleus.*—In the process of free cell-formation, as described above, we have alluded to the production of the nucleus as the first step of the process, and it is regarded as such in most instances by far the greater number of observers. In some cases, however, no nucleus can be detected in a cell previous to the formation of other cells free in its cavity; hence it is quite clear that the presence of the nucleus cannot always be regarded as essential, but that the separation of a portion of protoplasm from the general mass, which takes place under such circumstances, must be capable of acting as one, and thus to cover itself with a membrane and form a cell. This, according to Mohl, frequently occurs in the formation of the spores of the Algæ, &c.

In the ordinary course of vegetation, free cell-formation can only take place in the protoplasmic fluid contained in the interior of cells forming parts of living tissues, although, according to Schleiden, Mohl, and others, "it may also occur independently of the life of the parent plant in the creation of parasitic Fungi, Yeast cells, &c., both in the decomposing fluid of cells, and in the excreted or expressed juices."

2. Cell-division.—This mode of cell-formation is also called by authors *parietal cell-formation*, and *merismatic* or *fissiparous*. It may be treated of under two heads, namely: 1. *Cell-division without absorption of the walls of the parent cell*, and 2. *Cell-division with absorption of the walls of the parent cell, and the setting free of the new cells.*

1. *Cell-division without absorption of the walls of the parent cell.*—This mode of cell formation was first discovered by Mohl, whose opinions were afterwards ably supported by Henfrey and Mitscherlich. According to these physiologists, (and their observations have now been confirmed in all essential particulars by various subsequent observers,) this process is the one by which all vegetating or growing parts of plants, whether Flowering or Flowerless, are produced and increased;—all increase in the mass of the different organs is therefore due to its agency. The manner in which it takes place is as follows:—The primordial utricle or the protoplasmic lining of the cell,

becomes gradually constricted on all sides (*fig.* 141, *a*, *b*, *c*, *d*), thus folding inwards, and ultimately dividing by a kind of

Fig. 141.

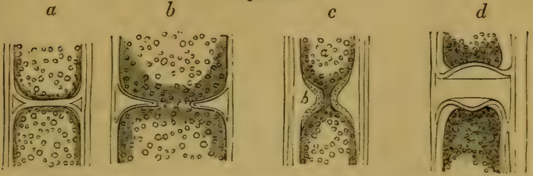


Fig. 141. *a*. Cell of *Conferva glomerata*, with the cell-contents constricted by the half-completed septum. *b*. A half-completed septum in which a considerable deposition of cellulose has already taken place. *c*. A septum in course of development, after the action of an acid, which has caused contraction both of the primordial utricle (*a*) and the cell-contents (*b*). *d*. Complete septum split into two lamellæ by the action of an acid. After Mohl and Henfrey.

hour-glass contraction the original primordial utricle and the contents of the cell within it into two distinct portions, each portion of the primordial utricle then secretes a layer of cellulose over its whole surface, and where these portions are in contact with the original wall of the primary cell they only form new layers of thickening to it, but when separated from the wall, as is the case where the infolding takes place, they form distinct cellulose membranes, which will be, however, continuous with those layers of thickening. The original cell thus becomes divided into two; each of these then has the power of growing until it reaches the original size of its parent, and then either, or both, may again divide in a similar manner until the plant, or organ, of which they form a part, is completed.

In this mode of cell-formation, it is by no means evident what function the nucleus performs. That this is unimportant is clear, because cell-division as above described may take place, as it does in some of the lower orders of plants, without the presence of that body. In the higher orders of plants, however, the original nucleus of the cell appears to undergo subdivision into two halves, as is the case with the other contents, so that a nucleus is thus formed for each new cell into which the parent cell has been divided. In other cases, however, separate nuclei are formed for the secondary cells, instead of the original nucleus dividing into two.

In some of the lower kinds of plants, a modification of this process of cell-division takes place; it consists in the formation of the secondary cells, as little bud-like prominences on the surface of the primary cells, either at their extremities, as in the Yeast plant (*fig.* 142), &c., by which the plant is increased in length; or on the side of the primary cell when branches are produced, as in some Confervæ (*fig.* 143), in the fibrilliform cells

of Fungi and Lichens, and in other cases; probably much more frequently than is commonly supposed. The mode in which

Fig. 142.

Fig. 143.

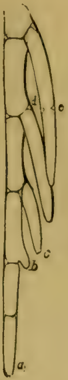


Fig. 144.

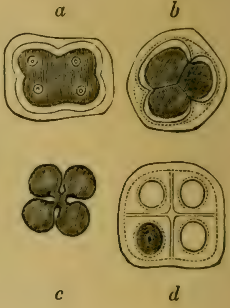


Fig. 142. Yeast plant in process of development.—— *Fig.* 143. *Conferva glomerata*, showing the progressive formation of ramifications (*b*, *c*, *d*, *e*) from its side. After Mohl.——*Fig.* 144. Formation of the pollen in *Althæa rosea*. After Mohl and Henfrey. *a.* shows four nuclei in the parent cell, and four septa commencing to be formed. The primordial utricle and cell-contents are contracted by the action of alcohol. *b.* The development of the septa more advanced. *c.* The primordial utricle removed from the parent cell, but not yet completely divided into four parts. *d.* The division of the parent cell into four parts completed.

this budding occurs may be thus described. At a certain point the primordial utricle appears to acquire a special development, for it is seen to bulge out, carrying the cellulose wall of the cell before it, by which a little prominence is produced externally (*fig.* 143, *b*), this continues to elongate until it forms a tubular projection, *c*, on the side of the primary cell. The cavity of this projection is at first continuous with that of the cell from whence it sprung, but after it has acquired a certain definite length, its primordial utricle becomes constricted at the point of contact with the primary cell, *d*, and ultimately forms a partition between them, as in the ordinary process of cell-division. In some cases, as in the formation of the fibrilliform cells of Fungi and Lichens, no partitions are formed but all the branches communicate with each other (*fig.* 10). This process of cell-division is termed *gemmation or budding*.

2. *Cell-division with absorption of the walls of the parent cell, and the setting free of the new cells.*—The pollen cells in the anthers of all Flowering Plants, and the spores of most Flowerless Plants, are formed by this process. The manner in which it

commonly takes place in the formation of pollen, is as follows :—(*fig.* 144) ; the primordial utricle of each parent cell becomes infolded as in ordinary cell-division, so as to divide it into four portions, either directly, or indirectly by first dividing it into two, and then each of these being again divided into two others ; these four portions are called *special parent cells;* the whole of the protoplasmic contents in each of these then secrete a layer of membrane on their outside, and we have thus four perfect cells formed in the cavity of their parent. As these continue to enlarge, the walls of the parent cells, and subsequently those of the special parent cells, become in most cases absorbed, and the cells being thus set free, the process is completed. The manner in which the spores are formed in the higher Flowerless Plants is substantially the same in most cases. It sometimes happens, however, that in the development of pollen and spores, the special parent cells are not formed, as has been shown by Schacht in the pollen of *Œnothera*, and in the spores of *Anthoceros lævis;* and by Henfrey in the spores of *Marchantia polymorpha* (*fig.* 145).

Fig. 145.

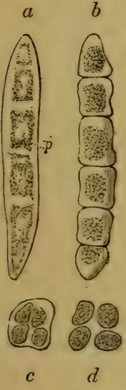


Fig. 146.

Fig. 145. *a.* Cylindrical cell from which are formed the parent cells of the spores of *Marchantia polymorpha; p.* Primordial utricle of the parent cells. *b.* The same cell converted into a string of cells. *c.* One of the parent cells isolated, with four primordial utricles of the spores. *d.* The four spores free. After Henfrey.——*Fig.* 146. Formation of zoospores in *Achlya prolifera.* After Carpenter.

In some cases, instead of the development of only four secondary cells in the cavity of the parent, we have a large number formed in this manner (*fig.* 146, A), which either escape (*fig.* 146, B) from it clothed by a cellulose coat, as is ordinarily the case, or this is secreted after their separation from the parent

cell, as in the *zoospores* of the Confervæ, &c. In this way various modifications of this process of cell-division occur, and have been described by authors, some of which are closely analogous, if not referrible to the ordinary process of *free cell-formation.* Our limits will not allow of our alluding further to those modifications. In conclusion we may remark that, while *ordinary cell-division* is the process by which all vegetating or growing parts are produced and increased, the *second process of cell-division*, and *free cell-formation* are especially concerned in the process of reproduction.

By the ordinary method of cell-division, cells are in many instances produced with almost inconceivable rapidity. Thus, it has been stated that a fungus of the *Puff-ball* tribe has been known to grow in a single night, in damp warm weather, from the size of a mere point to that of a large gourd, and it has been calculated, from the average size of the cells in such plants, that such a gourd must have contained at least *forty-seven thousand million* cells, so that they must have been developed at the rate of nearly *four-thousand millions* per hour, or more than *sixty-six millions* per minute. It must be recollected, however, that this rapid growth is not altogether owing to the production of new cells, but also to a great extent upon the expansion of those already formed. Another illustration of the rapid production of cells is afforded us in arctic and alpine regions, where it frequently happens that the snow over an extensive area is suddenly reddened by the cells of the Red Snow-plant (*Protococcus nivalis*) (*figs.* 147 and 148.) Again, it may readily be ascertained that in a favourable growing season, many stems will increase three or four inches in length in twenty-four hours, and the Agave or American Aloe (*Agave americana*), when flowering in our conservatories, has been known to develope its flower-stalk at the rate of at least a foot in a day, and in the warm climates where it is indigenous, as in the Mauritius, it will grow at least two feet in the same period of time. Leaves also in some cases develope very rapidly; thus Mulder states that he has seen the leaf of *Urania speciosa* lengthen at the rate of from one and a half to three and a half lines per hour, and even as much as from four to five inches per day. In this rapid growth of stems and leaves, it must be remembered as in the case of the growth of the *Puff-ball*, that such increase is due not only to the formation of new cells, but also to the expansion of those previously formed.

CHAPTER 2.

GENERAL MORPHOLOGY OF THE PLANT.

By the combination of the different varieties of cells and tissues which have been described in the preceding chapter, a variety of *compound organs* are formed; these again, by their union in various ways, form the individual plant; and according to their number, and the greater or less degree of complexity which they exhibit, so in a corresponding degree does the plant vary in those particulars. Hence we find plants exhibiting a great variety of forms. That part of Botany which has for its object the study of those forms and of their component parts is called Morphology.

The simplest plant merely consists of a single cell, which may vary much in its form; thus in the Red Snow-plant (*figs.* 147 and

Fig. 147.

Fig. 149.

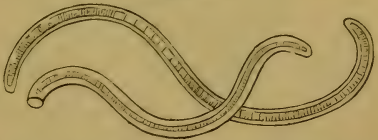


Fig. 148.

Fig. 148. Several Red Snow-plants (*Protococcus nivalis*), magnified.——*Fig.* 147. One plant still more highly magnified.——*Fig.* 149. Two plants of *Oscillatoria spiralis*.

148), it is *round;* in the Oscillatoria (*fig.* 149) *lengthened;* in others branched in various ways (*fig.* 17). In these simple plants we are unable to distinguish any separation of the vegetative and reproductive functions, which is so evident in the higher plants, but the cell of which they are composed is capable of performing both those functions. The plants immediately above these consist of numerous cells combined in a single row, and either simple (*fig.* 150), or branched (*fig.* 151) in a variety of ways (*fig.* 152). In these plants we frequently find one or more of the cells acquiring a special development, and producing in their interior a number of others of a smaller size (*fig.* 150). Here we have the first trace of a separation or distinction of the cells of

Fig. 150. Fig. 151. Fig. 152.

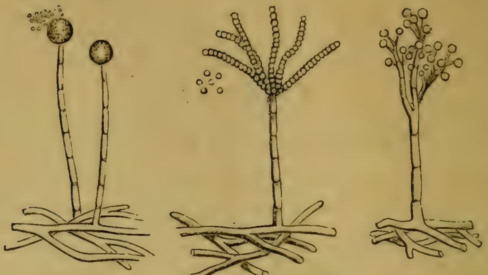


Fig. 150. A species of mould (*Mucor*), with mycelium below, from which two stalks are seen to arise, each of which is terminated by a sac (*cystidium*), from which a number of minute bodies (*spores*) are escaping. ——*Fig.* 151. Another mould (*Penicillium*), with mycelium and stalk bearing several rows of cells, which are the germinating spores. ——*Fig.* 152. Another mould (*Botrytis*), with mycelium and stalk, which branches above, and each ramification bears a rounded spore.

Fig. 153.

Fig. 153. Thallus of the common Bladder Sea-weed (*Fucus vesiculosus*). *t.* The fructification. *v.* Bladders of air.

a plant into those adapted for *vegetation*, and those for *reproduction*, as the smaller cells thus developed in the interior of the larger ones are especially designed for reproducing the plant, in the same manner as the seeds of Flowering Plants are adapted for that purpose. These reproductive particles are termed spores or sporules.

In the plants above these we find the cells combined in various ways, so as to form flattened leaf-like expansions (*fig.* 153), or solid axes, as well as special organs of reproduction.

Up to this point, however, although we have, as just noticed, certain cells containing reproductive particles, yet we have no examples of plants presenting any distinct axis bearing leaves. Such plants are therefore called *Thallophytes* or *Thallogens*, that is plants formed of a *thallus*, because the latter term is applied to any cellular filamentous or flattened leafy expansions, of whatever form, which have no axis or stem distinct from a leaf, but the two combined as it were together, and per-

forming the office of both. Under the head of Thallophytes we comprise those simpler forms of plants which are commonly known as Algæ, Fungi, and Lichens.

By various intermediate stages through an order of plants called the Liverworts (*figs.* 808 and 810), we arrive at a series of plants, viz. the true Mosses (*figs.* 154 and 155), which present us

Fig. 154. *Fig.* 156. *Fig.* 157.

Fig. 155.

Fig. 154.
Hair-moss (*Polytrichum*), with its leaves, stalk, and fructification.

Fig. 155.
The male plant, as it is commonly termed, of the Hair-moss, with its axis and leaves, and terminated by the supposed male organs (*antheridia*).

Fig. 156.
The common Club-moss (*Lycopodium clavatum*).

Fig. 157.
Fructification of the Great Water Horse-tail (*Equisetum Telmateia*).

with *an evident stem, bearing leaves.* In these also we find the first trace of roots, in the form of little tubular prolongations composed of cells proceeding from the lower part of the stem. In the Mosses, therefore, we have first distinctly shadowed forth

Fig. 158.

Fig. 159.

Fig. 158. The Male Fern (*Lastrea Filix-mas*).——*Fig.* 159. A Tree-fern showing a tuft of fronds at the apex of a cylindrical stem, which is enlarged at its base, *ra*, by the development of a mass of adventitious roots.

the three essential organs of the higher plants, namely a *root*, *stem*, and *leaf*. All plants, from the Mosses upwards, are presented to us under ordinary circumstances with a distinct

axis, commonly bearing leaves. Such are therefore termed *Cormophytes* or stem-producing plants, to distinguish them from the thallus-forming plants or *Thallophytes*, just alluded to.

All the plants previously noticed including the Mosses, are chiefly composed of parenchymatous cells, without any trace of wood-cells or vessels except in a few instances. These therefore, are frequently known as *Cellular Plants*, in order to distinguish them from all others which are placed above them, which from being generally furnished with both wood-cells and vessels, as well as parenchymatous cells, are called *Vascular Plants*.

The lowest orders of Vascular Plants, like the true Mosses, are comparatively insignificant in appearance, such as the Club-mosses (*fig.* 156); the Horse-tails (*fig.* 157); and even generally the Ferns so far as they are natives of cold and temperate regions (*fig.* 158), but in the tropics and warmer parts of the globe the latter plants frequently grow to a considerable height, and form handsome trees (*fig.* 159). These plants, however, like the Mosses and the Thallophytes, are all reproduced by Spores, and never produce evident flowers like the higher kinds of plants, hence, such were denominated by Linnæus *Flowerless* or *Cryptogamous Plants*, that is to say, plants with concealed or invisible reproductive organs. They were so called to distinguish them from all the orders of plants which are placed above them, and which from possessing evident reproductive organs are termed *Phanerogamous*, *Phænogamous*, or *Flowering Plants*. The latter plants are propagated by true *seeds* instead of spores ; a seed being essentially distinguished from a spore, from containing within itself in a rudimentary condition all the essential parts of the future plant in the form of an embryo (*fig.* 160); while a spore merely consists of a single cell, or of several united, and never exhibits any distinction of parts until it begins to develope in the ordinary process of vegetation, and then only in certain cases. The Phanerogamous plants are those therefore in which we have the highest and most perfect condition of vegetation, and to these our attention will be more particularly directed in the following pages. Before proceeding however, to describe in detail the different parts or organs which they present, it will be more convenient and intelligible to take a brief review of those organs.

Fig. 160.

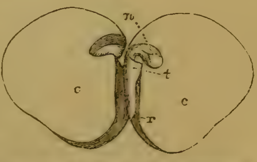


Fig. 160. Dicotyledonous embryo of the pea. *r.* The radicle. *t.* The axis, terminated by the plumule *n*; *c c.* the cotyledons or seed-lobes.

We have already stated that a seed contains an embryo, in which the fundamental organs of the future plant are present

in a rudimentary state. The embryo of a common pea may be taken for the purpose of illustration (*fig.* 160). Here we find a distinct central axis, *t*, the lower part of which is called the *radicle*, *r*; and it is terminated at its upper extremity by two or more rudimentary leaves, forming together what is termed the *plumule* or *gemmule*, *n*. This axis is united to two fleshy lobes, *c c*, whose office is of a temporary nature, to which the name of *cotyledons* or *seed-leaves* has been given. Some seeds only contain one cotyledon in their embryo (*fig.* 162, *c*); hence we divide plants which are propagated by them into two great classes, called respectively, Dicotyledons (*two cotyledons*), and Monocotyledons (*one cotyledon*).

When a seed is placed under favourable circumstances (which will be treated of hereafter in speaking of the process of germination), the embryo that it contains begins to develope itself (*figs.* 161 and 162); the lower part of its axis or radicle,

Fig. 161.

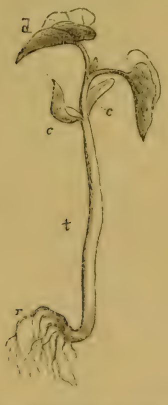


Fig. 162.

Fig. 161. Germination of the Haricot or French Bean, a Dicotyledonous Plant. *r*. The roots springing from the lower end of the axis. *t*. *t*. The axis. *c*, *c*. The cotyledons. *d*. The leaves.——*Fig.* 162. Germination of Maize, a Monocotyledonous Plant. *t*. The axis giving off roots from its lower extremity. *c*. The cotyledon. *g*. The leaves and young stalk.

or one or more branches from it, growing in a downward direction, while the upper part elongates upwards, carrying the plumule with it, while at the same time the cotyledonary portion becomes developed and forms the first leafy organs. We have thus produced a central axis developing in two opposite directions, the lower part is called the *descending axis* or

root, r; and the upper the *ascending axis* or *stem, t.* Upon this axis or its divisions all the future organs of the plant are arranged ; those which immediately succeed the cotyledons, *c*, constitute the true leaves of the plant, *d;* and all which succeed the leaves in the order of development, such as the flower and its parts, are merely modifications designed for special purposes of those organs which have preceded them. Hence the three organs, namely, stem, root, and leaves, which originally exist in the embryo in a rudimentary state, or are developed as soon as germination commences, are called the *fundamental organs of the plant.* They are also called *organs of vegetation* or *nutrition*, because they have for their object the nutrition and development of the plant to which they belong; while the flower and its parts have assigned to them the office of reproducing the plant by the formation of seeds, and are hence termed *organs of reproduction.*

In like manner, when a spore germinates, it either simply developes parts which perform equally both vegetative and reproductive functions ; or a certain special apparatus is designed for the latter purpose, as is the case in all the higher Cryptogamous Plants. We have here, therefore, as in Phanerogamous Plants, two manifestly distinct series of organs, one adapted for vegetation, another for reproduction. Hence in treating of the different organs of the plant, both in reference to their structure and functions we divide them into two divisions: namely, 1. *Organs of Nutrition* or *Vegetation*, and 2. *Organs of Reproduction.*

CHAPTER 3.

ORGANS OF NUTRITION OR VEGETATION.

Section 1. The Stem or Ascending Axis.

The stem may be defined as that part of the axis which at its first development in the embryo takes an opposite direction to the root, (hence it is termed the ascending axis), seeking the light and air, and bearing on its surface leaves and other leafy appendages. This definition will only strictly apply to a stem at its earliest development, for in numerous instances, soon after its appearance, instead of continuing to take an upward direction into the air, it will run along the ground, or even bury itself beneath the surface of the earth, thus withdrawing itself from the light and air and resembling a root, with which organ such a stem is commonly confounded. In these cases the stem is however at once distinguished from a root by the presence of modified leaves, each of which has the power of forming a leaf-bud in its axil (that is, in the angle produced by the junction of

the base of the upper surface of the leaf with the stem). The presence of leaves with leaf-buds in their axils is therefore the essential characteristic of a stem, in contradistinction to a root in which such organs are absent. All Flowering Plants, from the mode in which their axis is developed in the embryo (p. 68), must necessarily have a stem, although such stem may be very short. Those which have this organ clearly evident are called *caulescent*, while those in which it is very short or inconspicuous are termed *acaulescent* or *stemless*. In Flowerless Plants the stem is not necessarily present; thus it is absent in all Thallophytes.

1. Internal Structure of the Stem in general.—The simplest form of stem consists merely of parenchymatous cells. An example of such a stem may be seen, with few exceptions, in the Mosses and Liverworts. Such a structure however would be unsuited to plants in which great strength is required, and we accordingly find that in all plants above the Mosses the stem is made up partly of parenchymatous cells, and partly of wood-cells and vessels of different kinds, by which the requisite strength and toughness are produced. In these stems therefore we distinguish two systems as already noticed (p. 38), namely, a *Parenchymatous* or *common cellular system*, and a *Fibro-vascular*. The *parenchymatous* system grows in any direction according to circumstances, either longitudinally, by which the stem is increased in length, or horizontally, by which it is increased in diameter. The *fibro-vascular* system only grows longitudinally, and thus forms cords or bundles which are distributed vertically in the midst of the parenchymatous. The parenchymatous system is therefore also termed the *horizontal system* of the stem, while the *fibro-vascular* is likewise called the *longitudinal* or *vertical system*.

The differences which are found to exist in the internal structure of the stem of plants, are in a great measure owing to the different ways in which the fibro-vascular system is distributed in the parenchymatous. All these modifications may be, in their essential particulars, reduced to three great classes, two of which are found in Flowering Plants, and one in Flowerless. As illustrations of the two former we may take an Oak and a Palm stem; of the latter, that of a Tree-fern.

Upon making a transverse section of the Oak (*fig.* 163) we observe that the two systems of which the stem is composed are so arranged as to exhibit a distinct separation of parts. Thus we have a central one, *m*, called the *pith*; an external one, *e e*, or *bark*; an intermediate, *r*, or *wood*, dispersed in concentric layers; and little rays, *b*, connecting the pith and the bark, termed *medullary rays*. Such a stem grows in diameter by constant additions of new matter on the outside of its wood, and hence it is called Exogenous (from two Greek words signifying *outside*

growers). In a Palm stem no such distinction of parts can be noticed (*fig.* 164), but upon making a transverse section we

Fig. 163.

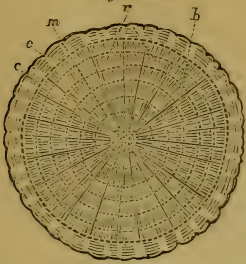


Fig. 164.

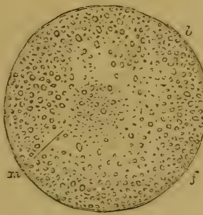


Fig. 163. Transverse section of an Oak-branch six years old. *m.* The medulla or pith. *c e.* The bark *r.* The wood. *b.* Medullary rays. —— *Fig.* 164. Transverse section of the stem of a Palm. *m.* The cellular substance. *f.* The fibro-vascular bundles. The whole being invested by a rind or false bark, *b.*

observe a mass of cellular substance, *m*, distributed throughout it, and the fibro-vascular arranged vertically in this in the form of separate bundles, *f*, which have no tendency to form layers of wood. This structure is called Endogenous (from two Greek words signifying *inside growers*), as such stems grow by the addition of new matter on their inside. Exogenous and Endogenous stems are those therefore which are characteristic of Flowering Plants. If we now turn our attention to Flowerless Plants, and make a transverse section of a Tree-fern (*fig.* 165), we observe the centre to be either hollow or filled with parenchymatous cells, *m*, the fibro-vascular system being arranged in irregular sinuous plates around this, *v v*, forming a continuous or interrupted circle near the circumference, which consists of a rind, *e*, inseparable from the wood beneath. This structure is termed Acrogenous (from two Greek words signifying *summit growers*), because such a stem grows only by additions to its summit.

Fig. 165.

Fig 165. Transverse section of the stem of a Tree-fern. *m.* Parenchymatous cells, which are wanting in the centre. *v, v.* Fibro-vascular bundles *e.* Rind.

According to the views first propounded by Schleiden, the

differences thus found to exist in the appearance and growth of these three kinds of stem are due to corresponding differences in their fibro-vascular systems, or as they are commonly called, *fibro-vascular* or *vascular bundles*. Thus the vascular bundle of an Exogenous stem (*fig.* 166) consists in the first year of growth of a layer of spiral vessels, *s v*, surrounding the pith, *p*; on the outside of this layer there are subsequently developed pitted and other vessels, and wood-cells, which together form the wood, *w*. In this case the growth of the different parts of the bundle is *progressive*, and the whole is covered externally by a layer of vitally active cells called the *cambium layer*, *c*, on the outside of which is the liber, *l*, and the other parts of the bark, *c e*. It is from the cambium that new layers of wood are formed, and from its position therefore on the outside of the vascular bundles, their growth is *indefinite*, as they are deposited in succession on the outside, and in continuity with the previous ones, as long as life continues. Hence such are called *indefinite vascular bundles*.

Fig. 166.

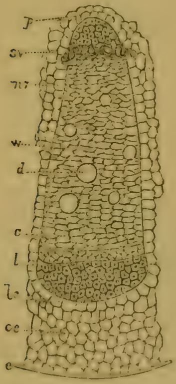


Fig. 167.

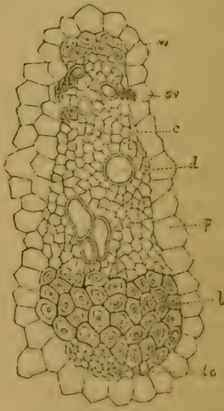


Fig. 166. Transverse section of a fibro-vascular bundle of an Exogenous stem (Melon). *p*. Pith. *s v*. Spiral vessels. *m r*. Medullary rays. *w*. Wood. *d*. Pitted vessels. *c*. Cambium. *l*. Liber. *l c*. Laticiferous vessels. *c e*. Cellular portion of the bark. *e*. Epidermal tissue.——*Fig.* 167. Transverse section of a fibro-vascular bundle of an Endogenous stem (Palm), the upper portion being directed to the centre. *w*. Wood-cells. *sv*. Spiral vessels. *c*. Cambium. *d*. Pitted vessels. *p*. Parenchyma. *l*. Liber-cells. *l c*. Laticiferous vessels.

In Endogenous stems the vascular bundles (*fig.* 167) consist internally of wood-cells, *w*, and spiral vessels, *s v*; on the outside

of which other spiral vessels are formed, as well as annular, pitted, and reticulated ones; these are bound together and succeeded by a number of delicate parenchymatous cells, and on the outside of these some laticiferous vessels, and at first a cambium region which is gradually converted into thick-sided prosenchymatous cells resembling those of the liber of Exogens. In this case the development of the vascular bundles, like those of Exogenous stems, is gradual, the inner part of each being first formed, and growth proceeds progressively to the outside, hence such are likewise progressive bundles, but, as such bundles have no external layer of growing cells resembling cambium, no increase in size takes place in them in successive seasons. Hence the new vascular bundles are not developed in continuity with the old, but remain distinct and of a limited size. Such vascular bundles are therefore named *definite vascular bundles*.

In Acrogenous stems the vascular bundles are chiefly made up of vessels of the scalariform, annular, or spiral type, according to the different orders of Acrogens from whence they have been derived; these are surrounded by delicate tubular cells, and the whole is enclosed by a firm layer of wood-cells. Such bundles only grow by additions to their summits, and as the elements of which they are composed are not formed in succession like those of indefinite and definite vascular bundles, but simultaneously, they are called *simultaneous vascular bundles*.

The distinctive appearances which we have thus seen to occur in the stems of the three plants above noticed are also accompanied by certain differences in the structure of their embryo. Thus plants with Exogenous stems have an embryo with two cotyledons; those with Endogenous stems have but one cotyledon in their embryo; while those with Acrogenous stems have no proper embryo, and consequently have no cotyledons. Hence exogenous stems are also termed *Dicotyledonous*; endogenous stems *Monocotyledonous*; and acrogenous stems *Acotyledonous*. For reasons which we shall describe hereafter, the latter terms are in some cases to be preferred to the former. In the succeeding pages we shall use them indiscriminately. With these general remarks on the structure of the three kinds of stems we now proceed to describe them respectively in detail.

A. Exogenous or Dicotyledonous Stem. — Those plants which possess exogenous stems are commonly termed Exogens, and they constitute by far the largest number of plants in every part of the globe. This kind of stem is alone found in the trees and shrubs of this country, and all the colder regions of the earth. In warmer climates it occurs associated with others possessing endogenous and acrogenous structure.

In the embryo state, the exogenous stem is entirely composed of parenchyma. But as soon as growth commences, some of its parenchymatous cells become developed into vessels and wood-

cells, so as to form the indefinite vascular bundles which are characteristic of such a stem. These bundles are at first separated from each other by large intervening spaces of parenchyma (*fig.* 168), but as growth proceeds they continue to enlarge, while at the same time new vascular bundles are formed between them, so that they ultimately form at the end of the first year's growth a zone of vessels and wood-cells round the central mass of parenchyma, interrupted only at certain points by cellular projections of this parenchyma, in the form of radiating lines. This zone is also surrounded by an external layer of cellular tissue which is connected with the central parenchyma by the radiating lines already alluded to. The stem then presents the following parts (*fig.* 168). 1. A central mass of parenchyma, *m*, which is called the *Medulla* or *Pith*; 2. An interrupted zone or ring of wood-cells and vessels, forming the *Wood*, *t*; 3. An external zone of parenchyma, or *Bark*; and 4. The radiating lines, *r*, connecting the pith and the bark, called the *Medullary rays*. On the outside of the wood is the cambium; and the bark is also invested by the epidermis already fully described. Such is the structure of all exogenous stems which die annually.

Fig. 168.

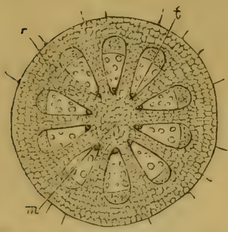


Fig. 168. Horizontal section of the first year's shoot of an Exogenous or Dicotyledonous stem. *m*. Pith. *r*. medullary rays. *t*. Spiral vessels forming the medullary sheath, on the outside of which are the other elements of the vascular bundle.

The stems of plants which live more than one year, as those of trees and shrubs, at first resemble those which are herbaceous or die yearly, except that the wood in such cases is generally firmer and in larger proportion. As growth proceeds in the second year, a new zone of wood is formed on the outside of that of the previous year (*fig.* 169, 2), while at the same time a new fibrous layer is added to the inside of the bark, *l*. These layers are developed out of the cambium cells *c*, already alluded to as forming a vitally active layer of cells on the outside of the indefinite vascular bundles which form the wood of Exogens. The medullary rays (*fig.* 171, *i*) at the same time increase by addition to their outside, and thus continue to keep up the connexion between the pith and the bark. In succeeding years we have in like manner new layers of wood and fibrous bark, one of each for every year's growth (*fig.* 169), while the medullary rays also continue to grow from within outwards. Each succeeding year's growth is therefore essentially a repetition of that of the first year, except as regards the pith, so that in old stems we have no more distinct regions than in those of the first year.

We have therefore in all exogenous stems but four separate parts, namely, pith, wood, medullary rays, and bark. We shall now describe these in the order in which they are placed.

Fig. 169.

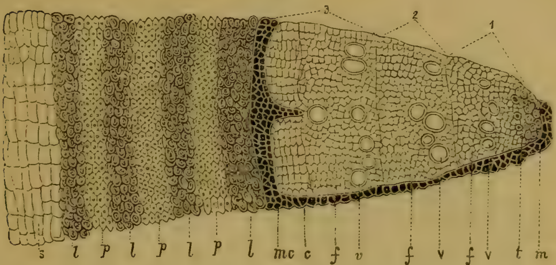


Fig. 169. Horizontal section from the centre to the circumference of the stem of the Maple, three years old. *m.* Pith. *t.* Spiral vessels. *v.* Pitted vessels. *f.* Fibres or wood-cells. *c.* Cambium layer. *s.* Epiphlœum; within which may be observed three cortical layers, marked *l p l, p l, p l,* corresponding to the three years' growth. The figures 1, 2, 3, refer to the three successive years' growth of the wood.

1. *Pith or Medulla.* (*Figs.* 169, *m*, and 171, *a.a.*) —This consists essentially of ordinary parenchyma, and forms a more or less cylindrical or angular column situated at or towards the centre of the stem. Under ordinary circumstances it is not continued into the root, but it is always in connexion directly with the terminal bud of the stem, and also at first indirectly by the medullary rays with all the lateral leaf-buds; as the latter, however, continue to develope, their connexion with the central pith is cut off, as will be explained hereafter in speaking of their structure and origin (p. 101). The parenchyma of which the pith is composed is generally that kind which is known as *regular* or *dodecahedral* (*figs.* 4 and 5), so that when a section is made of it, and examined microscopically, it presents a hexagonal, or polyhedral appearance. When first formed, the pith is commonly of a greenish colour, and the cells of which it is composed are filled with fluid containing nutrient substances dissolved in it. At this time it appears, therefore, to be in an active condition, and that such is the case is still further proved by the fact that its cells are often pitted from the deposition of secondary layers in

Fig. 170.

Fig. 170. Young branch of Walnut (*Juglans regia*) cut vertically to show its *discoid* pith.

their interior. Its activity, however, soon ceases, so that commonly after the first year it becomes nearly dry and colourless, and its cells filled with air. The pith also, then, instead of forming as at first a continuous column, becomes broken up at various points, so as to form irregular cavities in its tissue. This disruption may be especially seen in certain herbaceous plants which grow with great rapidity, as in the common Hemlock and others of the same family. In such cases it is almost entirely destroyed, merely remaining in the form of ragged portions attached to the interior of the stem. In some plants, such as the Walnut (*fig.* 170) and Jessamine, the pith is broken up regularly into horizontal cavities separated by thin discs only of its substance. It is then termed *discoid.*

The diameter of the pith varies much in different plants. It is generally very small in hard woody plants, as in the Ebony, Guaiacum. In the Elder it is large, and also in the Rice-paper Plant (*Aralia papyrifera*). The diameter not only varies in different plants, but also in different branches of the same; but when once the zone of wood of the first year is fully perfected, the pith which it surrounds can no longer increase, and it accordingly remains of the same diameter throughout the life of the plant.

The pith, as we have seen, is essentially composed of parenchyma. It also frequently contains laticiferous vessels, as may be readily observed by breaking asunder a young branch of the Fig-tree, when a quantity of milky juice at once oozes out from their laceration. In rare cases it also contains wood-cells, and in certain plants, as the large Umbelliferæ, we find spiral vessels in it. These however are probably only detached portions of the medullary sheath, separated in consequence of the great horizontal distension to which such stems are liable from the rapidity of their growth.

2. *The Wood.*—This is situated between the pith on its inside and the bark on its outer (*fig.* 163, *r*), and is separated into wedge-shaped bundles by the passage through it of the medullary rays (*fig.* 163, *b*). We have seen that in the first year's growth of an exogenous stem the wood is deposited in the form of an interrupted zone immediately surrounding the pith (*fig.* 168). That portion of the zone which is first developed consists chiefly of spiral vessels (*figs.* 168, *t*; 169, *t*; and 171, *d*), by which a thin sheath is formed, to which the name of *medullary sheath* is commonly applied. This does not however form a complete sheath to the pith, as its name would lead us to believe, but it is interrupted at certain points by the passage through it of the medullary rays (*fig.* 168, *r*). This is the only part of an exogenous stem in which spiral vessels normally occur. It appears to undergo less changes than any other part of the wood, so that its spiral vessels may be frequently unrolled, even

in old stems. In the wood of some plants, as the Broom-rapes, &c., no medullary sheath is formed.

On the outside of the medullary sheath, the zone of wood forming the first year's growth (*fig.* 171, 1) consists entirely of woody tissue (*c*), among which is distributed, more or less abundantly, some vessels (*b*), chiefly of the kind called pitted in

Fig. 171.

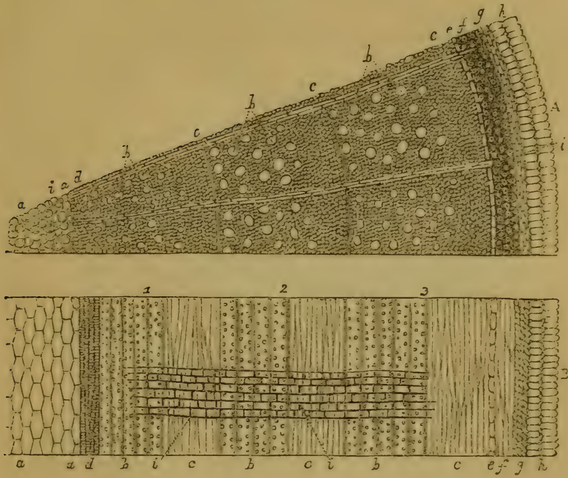


Fig. 171. **Diagram showing the structure of a Dicotyledonous stem three years old. A. Horizontal section. B. Vertical section. The figures 1, 2, 3, refer to the years of growth, and the letters mark similar parts in both sections. *a, a.* Medulla or pith. *d.* Spiral vessels. *b, b, b.* Pitted vessels. *c, c, c.* Wood-cells. *e.* Cambium-cells. *f.* Inner layer of bark, or liber (*endophlœum*). *g.* Middle layer of bark (*mesophlœum*). *h.* Outer layer of bark (*epiphlœum*). *i, i.* Medullary rays. After Carpenter.**

perennial plants; although in herbaceous plants we have also annular and other vessels. When the stem lasts more than one year a second zone of wood is formed, as we have seen, from the cambium cells placed on the outside of the first zone. This second zone (*fig.* 171, 2) resembles in every respect that of the first year, except that no medullary sheath is formed, it consists therefore entirely of woody tissue and pitted vessels (*c*, *b*). In the third year of growth another zone of wood is produced precisely resembling the second (*fig.* 171, 3), as is the case also with each succeeding annual zone as long as the plant continues to live. It is in consequence of each succeeding layer of wood being deposited on the outside of those of the previous years, that such

stems are called *exogenous*. In the stems of Coniferous Plants, as those of the Fir, Yew, Cypress, &c., the annual zones, which are well marked (*fig.* 172), consist chiefly of punctated woody tissue (see p. 13 and 30), with occasionally a few pitted vessels intermixed.

The pitted vessels, which we have seen form a portion of each annual layer of the wood, are so large in the Oak, Ash, &c., that they may readily be seen by the naked eye upon making a transverse section of such trees. Upon examining under the microscope a transverse slice of any common exogenous stem, the pitted vessels may be at once distinguished from the wood-cells by the larger size of their openings (*fig.* 169, *v*). In the Coniferæ, where but few if any pitted ducts occur, a transverse section shows the orifices nearly all of equal size, with occasionally a pitted vessel intermixed (*fig.* 172). These pit-

Fig. 172.

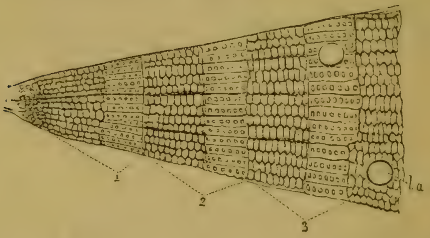


Fig. 172. Horizontal section of the stem of a Fir three years old. The figures 1, 2, 3, refer to the annual layers of wood. *l a*. Cavities containing resinous secretions.

ted vessels in ordinary trees are also commonly more abundant on the inner part of each annual zone, the wood-cells forming a compact layer on the outside. In such cases the limits of each zone are accurately defined. In those trees which have the pitted vessels more or less diffused throughout the woody tissue, as in the Lime, Maple, &c., the zones are by no means so evident, and can then only be distinguished by the smaller size of the wood-cells on the outside of each layer, which appearance is caused by their diminished growth towards the end of the season. The distinction between the annual zones is always most evident in trees growing in temperate and cold climates, where there is a more or less lengthened winter in which no growth takes place, followed by rapid vegetation afterwards. In the trees of tropical climates the zones are not so clearly defined, because there is no complete season of repose in such regions, although to a certain extent the dry season here leads to a cessation of growth, but the alternation of the growing

season and that of rest is not so well marked as in colder climates. As alternations of growth and seasons of repose may thus be shown to produce the appearance of annual zones, we can readily understand that if a plant were submitted to such influences several times in a single year it would produce a corresponding number of zones; and this does really occur in some plants of temperate climates, particularly in those which are herbaceous, where growth is more rapid than in hard-wooded perennial plants, so that the influence of such alternations is more evident. In tropical climates the production of two or more zones in a year is probably even more frequent than in temperate regions. In other trees again we have only one zone produced as the growth of several years, as in the Cycas, so that in such a case the number of zones by no means corresponds to the age of the tree. Lastly again, there are instances occurring in which no annual zones are formed, but the wood forms a uniform mass, whatever be the age of the plant, as in certain species of Cacti. Such appearances as the latter are however totally independent of climate, but are the characteristic peculiarities of some plants, and even of certain entire families.

The annual layers of different trees vary much in thickness, thus they are much broader in soft woods which grow rapidly, than in those which are harder and of slower growth. The influence of different seasons again will cause even the same tree to vary in this respect, the zones being broader in warm seasons than in cold ones, and hence we find the trees as we approach the poles have very narrow annual zones. The influence of soil and other circumstances will also materially affect the thickness of the annual zones in the same tree. We find also that the same zone will vary in diameter at different parts, so that the pith, instead of being in the centre of the wood, is more or less eccentric, owing to the zones being thicker on one side than on the other. This irregular thickness of the different parts of the annual zones is owing to several causes, but the greater growth on one side is chiefly due to the fact of its being more exposed to light and air than the other.

The annual zones also vary in thickness in the same tree, according to the age of that tree. Thus when a tree is in full vigour it will form larger zones than when that period is past, and it begins to get old. The age in which trees are in full vigour varies according to the species; thus the Oak, it is said, will form most timber from the age of twenty to thirty, and that after sixty years of age the amount formed will be much less considerable. Again, in the Larch, the vigour of growth appears to diminish after it is forty years of age; in the Elm after fifty years; in the Beech after thirty years; in the Spruce Fir after forty; and in the Yew after sixty years. Further observations are required however upon these points, which are of great

practical importance so far as growing trees for timber is concerned.

Duramen and Alburnum.—When the annual layers are first formed, the wood-cells and vessels of which they are composed are pervious to fluids. Their sides are then very thin and their cavities are gorged with *sap*, which, as will be afterwards seen, they are the chief agents in transmitting upwards from the root to the leaves. Their sides however, as they increase in age, become thickened by various deposits from the contained sap, by which their cavities are ultimately almost obliterated, and they are thus rendered nearly impermeable to fluids. This change is especially evident in the wood of those trees in which the incrusting matters are of a coloured nature, as in Ebony (*Diospyrus Ebenus*), Mahogany (*Swietenia Mahagoni*), Rose-wood (*Triptolemea species*), Lignum Vitæ (*Guaiacum officinale*), &c. Such coloured deposits are generally more evident in tropical trees, although they occur more or less in most of the trees of cold and temperate regions. In some, however, as in the Poplar and the Willow, the whole of the wood is nearly colourless, and exhibits no difference in the appearance of the internal and external layers. The value of wood as timber depends upon the nature of this incrusting matter, and is commonly in proportion to its colour; those woods, such as Ebony, Iron-wood, Mahogany, &c., which are deeply coloured, being far harder and more durable than the *white woods*, such as the Poplar, &c.

From the above characters which wood presents according to its age, we distinguish in it two parts: namely, an internal or central one, in which the wood-cells have thickened sides, are impermeable to fluids, hard in texture, coloured, and of a dry nature, which is called the *Duramen* or *Heart-wood;* and an outer part, in which the wood-cells have thin sides, are pervious to and full of sap, pale or colourless, and soft, to such the name of *Alburnum* or *Sap-wood* is given.

When the internal part of the wood has become of the nature of *heart-wood* it ceases to perform any active functions in the plant, its office being then chiefly to act as a support to it. All the vital and essential functions of the stem are then carried on by the *sap-wood*. Hence we see the reason why a tree in which the central part is completely destroyed, with the outer part or alburnum remaining, continues to live, put forth new branches, and add to its substance.

Age of Trees.—As each zone of wood in an exogenous stem is produced annually, it should follow that by counting the number of zones in a transverse section of any tree we ought to be able to ascertain its age, and this is true with a few exceptions, when such trees are natives of cold climates, because in these as we have seen, the annual zones are distinctly

marked. In exogenous trees, however, of warm climates it is generally difficult, and frequently impossible, to ascertain their age in this manner, in consequence of several disturbing causes; thus, in the first place, the zones are by no means so well defined; secondly, more than one zone may be formed in a year; thirdly, some trees, such as Zamias, the Cycas, &c., only produce one zone as the growth of several years; while lastly, in some, such as Guaiacum, &c., the zones are not only indistinct, but very irregular in their growth.

It has been stated that the age of a tree may be calculated, if its diameter is known, by the inspection of a fragment of that tree. The manner of proceeding in such a case is as follows:—Divide half the diameter of the tree divested of its bark by the diameter of the fragment, and then having ascertained the number of zones in that fragment, multiply this number by the quotient previously obtained. Thus: suppose the diameter of the piece to be two inches, and that of half the diameter of the wood twenty inches; then if there are eight zones in the fragment, by multiplying this number by ten, the quotient resulting from the division of half the diameter of the tree by that of the fragment, we shall get eighty years as the supposed age. Now, if the thickness of the zones was the same on both sides of the tree, and the pith consequently central, such a result would be perfectly accurate, but it happens from various causes as already noticed, that the zones are frequently much thicker on one side than on the other, and the taking therefore of a piece from either side indifferently would lead to totally different results. A better way therefore to calculate the age by the inspection of a portion is that suggested by DeCandolle; namely, to make two notches, or remove two pieces from opposite sides, and then, having ascertained the number of zones in each, take the mean of that number, and proceed as in the former case. Thus, suppose two inches as before, removed from the two opposite sides of a tree, and that in one we have eight zones, and in the other twelve, we have ten zones as the mean of the two. If we now divide, as before, half the diameter, twenty inches, by two, and multiply the quotient ten which results by ten, the mean of the number of zones in the two notches, we get one hundred years as the age of the plant under consideration. Such a rule in many cases will no doubt furnish a result tolerably correct, but even this is liable to lead to error, from the varying thickness of the annual zones produced by a tree at different periods of its age.

Dr. Lindley believes that DeCandolle in calculating the ages of different trees, was led into error by not sufficiently taking into account the variations in the growth of the annual zones at different periods, and their different thicknesses on the two sides; and, when we consider that some trees were estimated

by him to be more than 5000 years of age, we cannot but believe with Dr. Lindley, that such calculations give an exaggerated result. However erroneous they may have been, still there can be no doubt but that exogenous trees do live to a great age; in fact, when we consider that the new zones of wood are developed out of the cambium cells which are placed on the outside of the previous zones, and that it is in these new layers that all the active functions of the plant are carried on, there can be, under ordinary circumstances, no real limit to their age. Mohl believes that there is a limit to the age of all trees, arising from the increasing difficulty of conveying the proper amount of nourishment to the growing point, as the stem elongates from year to year. Thus, in some Coniferæ as *Pinus Lambertii*, and *Abies Douglasii*, which reach the height of more than 200 feet, he believes the maximum height which the sap was capable of rising to nourish the upper part of the plant was attained, and the terminal shoot being then less perfectly nourished, became every year more or less stunted, and the tree ultimately died from want of a proper supply of nourishment. We cannot however attach much importance to this opinion, because it is now known that a tree exists in California (*Wellingtonia gigantea*), which has reached the height of 450 feet, and is still in full vigour. This tree is supposed to be at least 3000 years old.

The following table is given by Lindley of the age of some trees, all of which, he states, can be proved historically:—

An Ivy near Montpelier	433 years.
Lime trees near Friburg	1230
„ „ Neustadt	800
Larch	576
Cedars, on Mount Lebanon . . .	6—800
Oaks	at least 1000

There can be no doubt, therefore, but that such trees will live beyond the above periods. Other trees, such as the Yew and Olive, may be added to the above list; thus, the Yew will certainly attain the age of 1200 years, and the Olive at least 800 years.

Size of Trees.—As there is no assignable limit to the age of exogenous trees in consequence of their mode of growth, so in like manner the same circumstance leads, in many cases, to their attaining great size. Thus the *Wellingtonia gigantea* has been measured 116 feet in circumference at the base. The Chestnut (*Castanea vesca*) of Mount Etna is 180 feet in circumference. A Plane tree (*Platanus orientalis*) near Constantinople is 150 feet in circumference. The Ceiba tree (*Bombax pentandrum*) is said to be sometimes so large that it

takes fifteen men with their arms extended to embrace it, and many other remarkable examples might be given of exogenous trees attaining to an enormous size, which circumstance is of itself, also an evidence of their great age. The necessary limits of this volume will not, however, allow of our dwelling further upon this subject.

Cambium or Cambium-layer. (*Figs.* 166, *c*, 169, *c*, and 171, *e*.) —On the outside of each annual zone (as we have already seen) a layer of vitally active cells is placed, to which the name of *cambium* or *cambium-layer* has been given. It is from this that the new layers of wood and bark are formed, and from the fact also of its being situated on the outside of the vascular bundles of which the wood is composed, these owe their indefinite power of increase. The cells of which the cambium layer is composed are of a very delicate nature, and consist of a thin wall of cellulose, within which is situated a primordial utricle, a nucleus, and abundance of protoplasm; in fact they contain all the substances which are present in young developing cells. This layer is dormant during the winter, at which time the bark is firmly attached to the wood beneath, but it is in full activity in the spring, when it becomes charged with the elaborated sap of the plant, or that sap which contains the materials necessary for the development of new structures, and then the bark may be separated from the wood beneath. It is proper to notice, however, that there is no real interval at any season between the bark and wood, but the two are always organically connected by the delicate cells forming the cambium-layer, and can only be separated therefore by the rupture of the cells of which that layer is composed. The sap which thus fills the cells of the cambium-layer was originally called cambium, and hence the name of cambium-layer applied to this portion of an exogenous stem. The cells of the cambium-layer as growth commences in the spring, when they are filled with protoplasm and other nitrogenous materials, soon begin to multiply by the ordinary process of cell-division already described. By their multiplication transversely the stem increases in a longitudinal direction, and by their multiplication perpendicularly, either radially or tangentially, the stem increases in thickness, and thus new layers of wood are formed on its inside, and new layers of bark on its outside.

3. *Medullary Rays.*—We have already seen that the stem at its first development consists entirely of parenchyma, but that in a short time fibro-vascular bundles are developed, by which it becomes separated into two portions — an internal or pith, and an external or bark; the two being connected by tissue of the same nature as themselves, to which the name *medullary rays* has been applied. These constitute the *silver grain* of

carpenters, because it is to their presence that many woods, such as the plane and sycamore, owe their peculiar lustre. As new layers of wood are formed in successive years, new additions are made to the ends of the medullary rays, by which means, however large the space between the pith and the bark ultimately becomes, the two are always kept in connexion by their means. Besides the medullary rays which thus extend throughout the entire thickness of the wood, others are also commonly developed between them in each succeeding year, which extend from the zones of those years respectively to the bark. These are called *secondary medullary rays*. In the Cork-oak both kinds may be well seen in a transverse section (*fig.* 173, 1, 2, 3, 4). The medullary rays are composed of flattened six-sided cells, which are placed one above the other in one or more rows, like the bricks in a wall (*fig.* 171, B, *i*, *i*; and *fig.* 52), hence the tissue which they form is commonly termed *muriform parenchyma*. It is a variety of *tabular parenchyma* as already noticed (p. 28). The tissue formed by the medullary rays is rarely continuous from one end of the stem to the other, but the rays are generally more or less interrupted by the passage between them of the fibro-vascular bundles, so that they split up vertically into a number of distinct portions. This arrangement may be observed by examining the surface of a

Fig. 173.

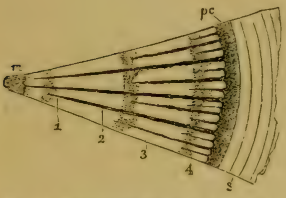


Fig. 173. Transverse section of a portion of the stem of the Cork-oak, four years old. *m*. Pith. 1, 2, 3, 4. Medullary rays of successive years. *pc*. Liber and mesophlœum. *s*. Corky layers.

Fig. 174.

Fig. 175.

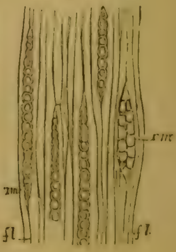


Fig. 174. Surface of the stem of a Dicotyledonous tree from which the bark has been removed.——*Fig.* 175. Vertical section of a branch of the common Maple, perpendicular to the medullary rays. *fl*. Fibro-vascular bundles. *rm*. Medullary rays.

stem from which the bark has been removed (*fig.* 174), or still better by making thin sections of the wood perpendicular

to the rays, that is tangential to the circumference of the stem (*fig.* 175). In some stems such as those of Aristolochia, the medullary rays are very conspicuous, forming large plates between the wedges of wood. In other plants, such as the Yew and Birch, they are comparatively small.

4. *The Bark or Cortical System.*—The bark is situated on the outside of the stem, surrounding the wood, to which it is organically connected by means of the medullary rays and cambium-layer. At those periods of the year when the cells of the cambium-layer are charged with sap it may be separated by a slight force from the wood beneath, but such separation can only be effected, as we have seen, by the rupture of the cells of which it is composed.

When the stem is first formed the bark is composed of parenchyma, like the pith, but as soon as the wood begins to be developed on the outside of the pith another layer of woody tissue, consisting of liber-cells, is deposited on the inside of the bark, so that the latter ultimately consists of two distinct systems; namely, an *internal* or *fibro-vascular*, and an *external* or *parenchymatous*. The parenchymatous system also exhibits in all plants destined to live for any period a separation into two portions, and the whole is covered externally by the epidermis already described. The bark accordingly presents three distinct layers, independently of the epidermis, which is common to it with other external parts. These three layers are called, proceeding from within outwards, 1. *Liber* or *Inner Bark*, or *Endophlœum* (*figs.* 176, *d*, and 171, *f*); 2. *Cellular Envelope* or *Green Layer*, or *Mesophlœum* (*figs.* 176, *c*, and 171, *g*); and 3. *Suberous* or *Corky Layer*, or *Epiphlœum* (*figs.* 176, *b*, and 171, *h*). We shall first describe the *liber*.

Fig. 176.

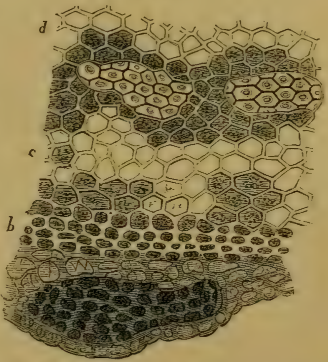


Fig. 176. Transverse section of a portion of the bark of a Dicotyledonous stem. *a.* Epidermis. *b.* Epiphlœum. *c.* Mesophlœum. *d.* Endophlœum. After Lindley.

a. *The Liber* or *Inner Bark*, or *Endophlœum*. (*Figs.* 176, *d*, and 171, *f*.)—This is composed of that variety of woody tissue

which is called bast tissue or woody tissue of the liber, mixed with some laticiferous vessels and parenchymatous cells. Some authors confine the term liber to that part of the inner bark which contains liber-cells, but it is best to extend this name to all that portion which is situated between the cambium-layer on its inside and the green layer of the bark on its outside. It is used in the latter sense in this volume. We have already, under the head of *Woody Tissue of the Liber*, fully described the characters of the liber-cells and their value for manufacturing purposes (see p. 30).

The liber-cells are sometimes placed side by side in a parallel direction, and thus form by their union a continuous layer as in Negundo, Horsechestnut, &c. ; more frequently however they present a wavy outline, and hence only touch each other at certain points, so that numerous interspaces are left between them, in which the medullary rays connecting the bark and the pith may be observed. From this circumstance the inner bark presents frequently a netted appearance, which is especially remarkable in that of the Lace-bark tree (*Lagetta lintearia*) of Jamaica, and of other plants belonging to the same natural order.

b. *The Cellular Envelope* or *Green Layer*, or *Mesophlœum*. (*Figs.* 176, *c*, and 171, *g*.)—This layer lies between the *liber* and *epiphlœum*, and hence the name *Mesophlœum* which is applied to it. It is connected on its inner surface with the medullary rays. It consists of thin-sided, usually angular or prismatic, parenchymatous cells, which are loosely connected, and thus leave between their sides a number of intercellular cavities. The cells of which it is composed contain an abundance of chlorophyll, which gives the green colour to young bark, and hence the name of *green layer*, by which it is commonly distinguished. This is the only part of the bark which usually possesses a green colour. In this layer also, as in the liber, we find generally some laticiferous vessels.

c. *The Corky Envelope*, or *Epiphlœum*. (*Figs.* 176, *b*, and 171, *h*.) This is the outer layer of the bark proper, and is invested by the epidermis (*fig.* 176, *a*). It has also received the names of *phlœum* and *periderm*. This term *periderm* is, however, sometimes used, as by Weddell, to indicate the dead portion of the bark, or that which has ceased to perform any active part in the life of the plant; which is commonly the case, as we shall presently see, in a few years with the two outer layers. Hence in this sense the periderm may consist of epiphlœum alone, or of mesophlœum chiefly, or of portions of both, or even in some cases of a portion of the liber. Those botanists who adopt this nomenclature, in such cases, apply the term *derm* to the inner living portion of the bark.

The epiphlœum consists of one or more layers of flattened tabular or cubical cells, which are generally elongated more or

less in a radial direction, and form by their union a compact tissue, commonly without interspaces. It is this layer which gives to the young bark of trees and shrubs their peculiar hues, which are generally brownish or some colour approaching to this, or sometimes it possesses more vivid tints. It is rarely coloured green, which is the case in Negundo, according to Gray, from its inner cells containing chlorophyll. In some plants, as in the Cork-oak (*Quercus Suber*) (*fig.* 173, *s*), this layer becomes excessively developed and forms the substance called *cork*, and hence the name *corky* or *suberous layer* which is frequently applied to it. Large developments of cork also occur on some other trees, as various species of Elm (*Ulmus alata*, *racemosa*, &c.). It commonly happens that the cells of which the epiphlœum is composed have not all the same appearance and colour. Thus in the Cork-oak some are more tabular or compressed and darker-coloured than others which alternate with them, so that the whole layer appears to be subdivided into several secondary layers. In the Birch, again, this distinction into layers is remarkably evident (*fig.* 177). Here a number of layers of dark-coloured firmly compacted tabular cells, *a*, may be seen alternating with others of a loose nature and of a white colour, *b*.

Fig. 177.

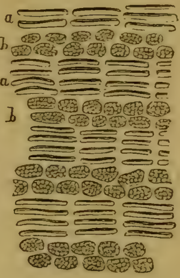


Fig. 177. Transverse section of a portion of Birch-bark. After Gray. *a*, *a*. Compact tabular cells. *b*, *b*. Layers of loose thin-walled cells alternating with the former.

Growth of the Bark.—The bark developes in an opposite direction to that of the wood, for while the latter increases by additions to its outer surface, the former increases by additions to its inner. The bark is therefore endogenous in its growth. Each layer also grows separately; thus the liber by the addition of new matter from the cambium-layer on its inside; the mesophlœum by the addition of cells next the liber; and the epiphlœum by cells next to the mesophlœum. The two outer layers, constituting the cellular system of the bark, rarely continue to grow after a few years, but become dead structures on the surface of the tree. The inner bark, however, continues to grow throughout the life of the individual, by the addition of annual layers on its inner surface from the cambium-layer. In some trees these layers may be readily observed, at least up to a certain period, as in the oak (*fig.* 163). They are commonly so thin when separated that they appear like the leaves of a book, and hence the supposed origin of the term *liber*

applied to the inner bark. The name liber is, however, sometimes considered to be derived from the inner bark of trees having been formerly used for writing upon. This distinction of the liber into layers is generally soon lost, in consequence of the pressure to which it is subjected from the growth of the wood beneath, which increases as we have seen, by additions to its outer surface.

The outer layers of the bark, from the distension to which they are exposed from the growth of the wood beneath, generally become cracked in various directions and assume a rugged appearance, as in the Elm and Cork-oak. In some trees, as the Beech (*Fagus sylvatica*), the bark, however, always retains its smoothness, which circumstance arises, partly from the small development of the cellular layers, and partly from their great distensibility. Other smooth-barked stems, such as those of the Holly, Ivy, &c., owe their peculiarities in this respect to similar causes.

When the bark has thus become rugged, it is commonly thrown off in large pieces, or in thick plates of various sizes. In the Birch and the Cherry, &c., the epiphlœum separates in thin transverse plates, which have a silvery appearance. In some plants, such as the Vine, Honeysuckle, &c., each layer of liber as it is developed throws off that of the preceding year, so that the bark always presents a fibrous character, and a similar appearance is produced in some other trees when they have arrived at a certain age. In other trees, as the Plane, a layer of delicate cells, analogous to the epiphlœum, is formed beneath each layer of liber, so that the two layers alternate with each other; these soon dry up in the outer layers, and the liber thus separates in plates year by year. In many Coniferous Plants, such as the Larch and common Pine, the cellular envelope becomes extensively developed, by which a kind of *false cork* is produced, which soon comes off in scales. The epidermis in all cases separates early from the epiphlœum, by which it is replaced.

By this exfoliation and peeling off of portions of the bark, its thickness is continually diminished. This decaying and falling away of the old bark does not in any way injure the tree, hence it is evident that the old layers of the bark, like the inner layers of the wood, have nothing to do with its life and growth after a certain period. The new layers of wood, the cambium-layer, and the recently formed liber, are the parts of an exogenous stem which are alone concerned in its active development and life.

Having now described the different parts which enter into the structure of an exogenous or dicotyledonous stem, we will in conclusion recapitulate them, and place them in a tabular form :—

1. *Pith* or *Medulla*, belonging to the parenchymatous system.
2. *Medullary Sheath*, composed chiefly of spiral vessels.
3. *Woody Layers*, one of which is formed annually on the outside of the previous layers, and consists of Wood-cells and Pitted Vessels.

   These (2 and 3) belong to the fibro-vascular system, and together form the wood properly so called.
4. *Medullary Rays*, consisting of cellular plates connecting the pith and the bark.
5. *Cambium-Layer*, composed of vitally active cells, from which new layers of wood and liber are formed.
6. *The Bark*, composed of two systems.
   1. *Inner Bark* or *Endophlœum*, or *Liber*, formed of liber-cells chiefly, and belonging to the fibro-vascular system, increasing by the annual addition of new layers on its inner surface.
   2. *Outer Bark*, composed of parenchyma, and hence belonging to the parenchymatous system, and consisting of
      a. *Cellular Envelope* or *Mesophlœum*, giving the green colour to bark.
      b. *Corky Layer* or *Epiphlœum*.
7. *The Epidermis*, which invests the epiphlœum in young stems; it is replaced after a certain age by the epiphlœum.

B. Endogenous or Monocotyledonous Stem.—In our country we have no trees or shrubs which exhibit this mode of growth, although we have numerous herbaceous plants, such as Grasses, Rushes, Sedges, &c. In our gardens again we have various kinds of Lilies, Yuccas, Tulips and other bulbous plants, which are also endogenous in their structure. It is in the warmer regions of the globe, and especially in the tropics, where we find the most striking and characteristic illustrations of Endogens; and of all these the Palms are by far the most remarkable. The appearance of such plants, even externally, is very different from those of exogenous trees, for endogenous plants have commonly no branches, but their stems are almost uniformly cylindrical from below upwards, frequently rising to the height of 150 feet or more, and crowned at their summits by a magnificent tuft of leaves (*fig.* 178, 1).

When we make a transverse section of a Palm stem, it presents, as we have seen (page 71), no distinction of pith, wood, medullary rays, and bark, but the cellular system is scattered more or less over the entire surface (*figs.* 164, *m*, and 179, A, *a*), the fibro-vascular being dispersed vertically in this, in the form of separate bundles, which have no tendency to collect together so

Fig. 178.

Fig. 178. 1. Unbranched stem of the Cocoa-nut Palm (*Cocos nucifera*). 2. Branched stem of *Pandanus odoratissimus*. The figures are placed at their base to indicate their height. From Jussieu.

as to form zones of wood, as in exogenous stems (*figs.* 164, *f*, and 179, *b*, *c*, *d*). The whole is covered externally by a fibrous and cellular layer, called the *false bark* or *rind* (*fig.* 164, *b*); but such is not a distinct and parallel formation to the wood as the bark of Exogens, but it is formed by the ends of the vascular bundles, as will be presently noticed, and cannot therefore be separated from the mass beneath. In herbaceous endogenous stems the general cellular or medullary substance between the vascular bundles is soft and delicate, but in such trees as the Palms, &c., the cells become hardened by the deposition of secondary layers upon their inner surfaces, thus forming what has been termed *woody parenchyma*, which ultimately binds the

Fig. 179.

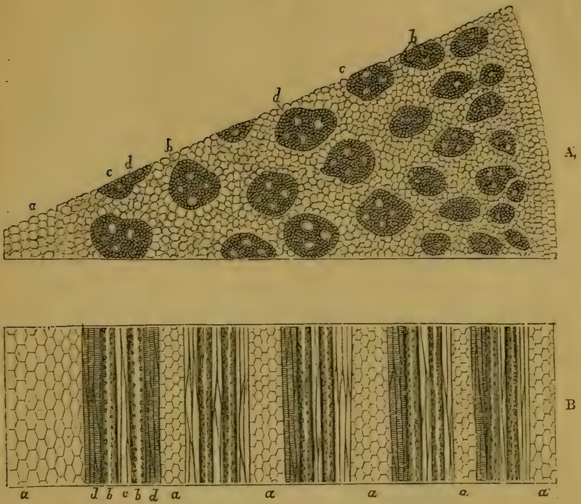


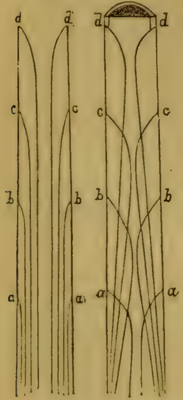
Fig. 179. Diagram of a Monocotyledonous stem. A. Transverse section. B. Vertical section. *a, a.* Parenchymatous tissue. *b, b.* Pitted vessels. *c, c.* Woody fibres or cells. *d, d.* Spiral vessels. After Carpenter.

original separate bundles into a solid hardened mass resembling wood.

The structure of the vascular bundles thus dispersed in the cellular substance of the stem, we have already described under the head of *Definite Vascular Bundles* (see page 72 and *fig.* 167). It was formerly supposed that these bundles, as they were successively developed, were directed towards the centre of the stem, and continued their course in the same direction towards its base (as seen in *fig.* 180, *a*, *b*, *c*, *d*), the last-formed bundles being the most internal, and gradually pushing towards the circumference those which had previously been developed. Hence the name *endogenous* or *inside growers*, by which these stems are commonly known. The researches of Mohl first showed that the above mode of growth was not strictly correct, but that the following is that which really takes place:—The vascular bundles have their origin in the *punctum vegetationis* of the stem, and are fully developed with its growth upwards and outwards into the leaves, and downwards and outwards towards the circumference. In other words, to render it more simple, the

bundles may be traced to the leaves, from which organs they are at first directed towards the interior of the stem (*fig.* 181, *a*, *b*, *c*, *d*), along which they descend generally for some distance, and then gradually curve outwards again and terminate at the circumference in the rind or false bark, or in young stems some of them reach the roots. When we make a vertical section therefore of an endogenous stem, we find these vascular bundles intersecting each other in various ways, as shown in *fig.* 182.

Fig. 180. *Fig.* 181.



Figs. 180 and 181. Diagrams showing the course of the fibro-vascular bundles of a Monocotyledonous stem. *a*, *b*, *c*, *d*. Fibro-vascular bundles.——*Fig.* 180 exhibits the course of the bundles as formerly supposed.——*Fig.* 181, according to Mohl's system, as now proved to be correct.

The vascular bundles in their course down the stem generally become more attenuated, which circumstance arises from certain differences which take place in their structure as they descend. Thus when they first originate they consist, as we have seen (see p. 72), of spiral, annular, and other vessels, mixed with parenchymatous and liber-cells. In their descent they gradually lose the spiral and other vessels, so that when they terminate at the circumference they consist chiefly of liber-cells bound together by parenchyma. The *rind* or *false bark* of endogenous stems is thus chiefly formed of the ends of the vascular bundles which originate in the leaves, and hence we see the principal reason why the latter cannot be separated, as in exogenous stems, from the wood beneath.

Fig. 182.

Fig. 182. Vertical section of the stem of a Palm, showing (*fv*) the vascular bundles intersecting each other as they pass downwards.

It follows from the mode of growth of the vascular bundles, as indicated above, that the term *endogenous*, commonly applied to such stems, is not altogether correct, as the bundles are only endogenous for a portion of their course, as they terminate ultimately at the circumference. This term endogenous has been therefore altogether discarded of late years by many botanists, who use instead, one which is derived from the structure of the embryo of such plants which we have seen possesses but one cotyledon, and hence their stems are called Mono-

cotyledonous. In this volume we generally use the term endogenous, because it is the one by which such stems have been known for a long period, and is accordingly that which is best understood.

As the vascular bundles of an endogenous stem, in the course of their successive development, are always deposited at first towards the centre, it must necessarily follow that those previously formed will be gradually pushed outwards, for which reason the outer part of a transverse section will always exhibit a closer aggregation of bundles than the inside (*figs.* 164 and 179, A). In such stems, therefore, the hardest part is on the outside, and the softest inside, directly the reverse of what occurs in those of exogenous growth. The lower portion of such stems also, in consequence of the descent of the vascular bundles, which become, moreover, more incrusted by secondary deposits, will become harder than the upper. The rind in like manner, at the lower part, will become harder, from the greater number of liber-cells which terminate in it. As endogenous stems increase in diameter, partly by the deposit of vascular bundles in their interior, and partly by the general development of the cellular tissue in which they are placed, it follows that as soon as the rind or false bark has become thus hardened by the liber-cells, it is not capable of further distension; the stem, therefore, becomes at length choked up by the descending bundles, and growth is no longer possible. It is evident, therefore, that endogenous stems, unlike those of exogenous, cannot grow in diameter beyond a certain limit, and that from the same causes also they cannot live beyond a certain age. Although, as a general rule, the stems of Palms and most Endogens are thus limited in size and life, there are some remarkable exceptions to this, as for instance in *Yuccas*, the *Dracænas* or *Dragon-trees* (*fig.* 186), &c.; in these the rind is always soft and capable of distension, and the vascular bundles, after having reached it, are continued downwards as fibrous layers between it and the original vascular bundles, and thus form a sort of wood beneath, in successive layers, somewhat after the manner that layers of wood are produced by the cambium-layers of Exogens. Such endogenous stems, therefore, like those of exogenous, have no limit either to their size or age.

It is in consequence of the comparatively small increase in diameter which most endogenous stems undergo, that twining plants which encircle them do them no injury, frequently not even producing the slightest swelling on their surface, and thus proving incontestably that such stems do not increase in diameter after a certain age. The effect of such climbers is well seen in *fig.* 184. If we compare this figure with that of an exogenous stem (*fig.* 183), with a woody twining plant encircling it, we find a striking difference; for here we observe exten-

Fig. 183. *Fig.* 184.

Fig. 183. Dicotyledonous stem, with a woody twining plant around it.
Fig. 184. Monocotyledonous stem, encircled by a woody twiner.

sive swellings produced, which exhibit a corresponding increase of the diameter of the stem. Such a comparison shows, in a very striking and conclusive manner, the characteristic peculiarities of the growth of exogenous and endogenous stems.

In a Palm stem, as we have seen (*fig.* 178, 1), there are commonly no branches; such stems having no power of forming lateral buds from which they are produced. These plants therefore grow simply by the development of a terminal bud, which when it unfolds covers the summit with a plume of foliage. Such stems are accordingly nearly of the same diameter below as above, and thus form a cylindrical column. In such trees the destruction of the terminal bud necessarily leads to the death of the plant, as it is then deprived of all mode of increase. In some endogenous trees however more than one bud is developed: thus, in the Doum Palm of Egypt (*Hyphæne thebaica*), two are formed, so that the stem is forked above (*fig.* 185); each

Fig. 185.

Fig. 185. The Doum Palm of Egypt (*Hyphæne thebaica*).

Fig. 186.

Fig. 186. The Dragon Tree of Teneriffe (*Dracæna Draco*).

branch again developes two other buds at its apex in like manner, and this mode of growth is continued with the successive branches, which are therefore also forked. In other Endogens we have lateral buds formed as in Exogens; this is the case in the Asparagus, in the Screw Pine (*fig.* 178, 2), in the Dracænas (*fig.* 186), &c. As the lower part of such stems receives more vascular bundles than the upper they are necessarily larger in their diameter at that part, and thus these stems are conical or taper upwards like those of Exogens.

Some Endogens present an anomalous structure; thus in most Grasses the stem is hollow (*fig.* 187), except at the points where the leaves arise, at which parts solid partitions are formed across the cavity, by which it is divided into a number of separate portions. Such stems when examined at their firstdevelopment present the usual appearance of Endogens, but in consequence of their growth in diameter taking place more rapidly than new matter can be deposited in their interior, they soon become hollow.

In some other Endogens we have a more striking deviation from the ordinary structure. Thus the Sarsaparillas and a few other allied plants have aerial stems which are strictly endogenous, and underground stems which have the vascular bundles arranged in one or two zones surrounding a central cellular substance (*fig.* 188), like the wood around the pith

of Exogens, but such bundles have no cambium-layer on their outside, and have consequently no power of indefinite increase as is the case with exogenous stems.

Fig. 188.

Fig. 187.

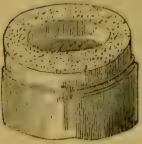


Fig. 187. Transverse section of the stem of the common Reed.——*Fig.* 188. Section of the underground stem of a species of Sarsaparilla. *a.* Epidermal tissue. *b, c, d.* The cortical portion. *e.* Woody zone. *f.* Medulla or pith.

There is nothing in the internal structure of endogenous stems by which we can ascertain their age as we can those of exogenous. It was formerly supposed that the age of a Palm stem was indicated by the annular scars produced on its external surface by the fall of the leaves, each ring being supposed to be equivalent to a year's growth (*figs.* 178 and 185). These rings are however by no means to be depended upon as indications of the age of such trees, for there are frequently several rings produced in one year, and these again often disappear after having existed for a certain period. The best means of ascertaining the age of Palms is by noting their increase in height in one year's growth, and then as such stems grow almost uniformly in successive years, by knowing their height we can determine their age. This mode however of calculating their age is very liable to error, and we cannot therefore be considered at present to possess any certain means of determining the age of endogenous stems.

C. Acrogenous or Acotyledonous Stem. — The simplest form of stem presented by Acotyledonous Plants is that of Mosses and Liverworts. In their stems we have no true vessels, but the whole is composed of ordinary parenchyma, with occasionally a vertical central cord of wood-cells. In the stems of Club-mosses (*Lycopodiaceæ*), Pepperworts (*Marsileaceæ*), and Horsetails (*Equisetaceæ*), we have the simplest forms of acrogenous stems which contain vessels and the peculiar vascular bundles (*Simultaneous*), which are their especial characteristics. The composition of these vascular bundles and their mode of growth

have been already described. (See page 73.) The vessels found in the vascular bundles of the Lycopodiaceæ are *spiral*, and in those of the Equisetaceæ *annular* All Acotyledonous stems grow by additions to their apex, and hence the term *Acrogenous* or summit growers, which is applied to them.

In the Ferns (Filices), we have the Acrogenous stem in the highest degree of development. Those which are indigenous to this country are but insignificant specimens of such plants, for in them the stem merely runs along the surface of the ground, or burrows beneath it, sending up its leaves, or *fronds* as they are commonly called, into the air, which die down yearly (*fig.* 158). In warm regions, and more especially in the tropics, we find such plants in the highest degree of development. Here the stem, called the *caudex* or *stipe*, rises into the air to the height of fifty or sixty feet or more (*fig.* 159), bearing on its summit a tuft of foliage. In their general appearance externally these Tree-Ferns have great resemblance to Monocotyledonous trees, not only in bearing their foliage like them at their summits, but also in producing no lateral branches, and being of uniform diameter from near their base to their summits. The outside of the stem of a Fern is marked with a number of *scars*, which have a more or less rhomboidal outline (*fig.* 189). The surface of these scars present little hardened projections, *c*, or darker-coloured spots, which appearance is produced by the rupture of the vessels proceeding to the leaves, by the fall of which organs the scars are produced.

Fig. 189.

Fig. 189. Rhizome of Male Fern, marked externally by rhomboidal scars, which present dark-coloured projections, *c*.

Upon making a transverse section of a Tree-Fern it presents, as we have already briefly noticed (see page 71), the following parts: — On the outside a hard rind (*fig.* 165, *e*), composed of dark-coloured wood-cells covered externally by parenchyma. Within this we find a mass of parenchyma, *m*, the cells of which have thin walls. This is analogous to the pith of exogenous stems. In old stems this central parenchyma is destroyed, so that the stem becomes hollow. Towards the outside of this cellular mass, and just within the rind, we find the wood consisting of simultaneous vascular bundles arranged in the form of plates, which, when cut, have a wavy outline, *v*, *v*. These masses of wood forming the fibro-vascular system have generally openings between them, by means of which the parenchyma beneath the rind and that of the centre of the stem communicate ; in other cases these woody masses touch each other at their edges, and thus form a continuous circle

within the rind. These masses consist of simultaneous vascular bundles, the vessels of which are chiefly scalariform; these are situated in the centre of the bundles, where they may be readily distinguished by their pale colour (*fig.* 165), and are surrounded externally by layers of dark-coloured hardened wood-cells.

We have already stated that Tree-Ferns have no branches. This arises from their having no provision for lateral buds: hence the cylindrical form of stem which is common to them. For the same reason also, they are rarely of great diameter. Some Ferns however become forked at their apex (*fig.* 190); this is produced by the division of the terminal bud into two, from each of which a branch is formed. Such branches are, however, very different from those of Exogens, which are produced from lateral buds, for, as they arise simply from the splitting of one bud into two, the diameter of the two branches combined is only equal to that of the trunk, and in all cases where the stems of Acotyledonous Plants branch, the diameter of the branches combined is only equal to that of the axis from whence they are derived. As Acotyledonous stems only grow by the development of a terminal bud, the destruction of that bud necessarily leads to their death. There is nothing in the internal structure or external appearance of such stems by which we can ascertain their age.

Fig. 190.

Fig. 190. Forked stem of a Tree-Fern.

All Acotyledonous Plants below the Mosses and Liverworts have no true stems bearing leaves, as we have already seen (see p. 64), but they simply form cellular expansions of various kinds, to which the name of *thallus* is applied, hence they are termed *Thallophytes* or *Thallogens*; while all plants producing stems are called *Cormophytes*, and these are divided according to their internal structure into three great classes called respectively Exogens or Dicotyledons, Endogens or Monocotyledons, and Acrogens or Acotyledons. The nature of the internal structure of the stem has been now fully treated of, and we proceed to describe the buds which are situated upon the surface of stems, and by means of which, as already briefly noticed, they increase in height and form branches.

2. Buds and Ramification. — We have already stated (p. 70) that one of the main characteristics by which a stem is distinguished from a root is the presence of leaves and buds. The leaves will be particularly treated of hereafter, but we have now to describe the parts of the stem from whence they arise, and the nature of buds.

Leaves are always developed at regular points upon the surface of the stem, which are called *nodes* or simply *knots*, and

the intervals between them *internodes*. Generally the arrangement of the tissue of the stem at the nodes, is somewhat different from that of the internodes; thus it exhibits a more or less contracted or interrupted appearance, which arises from a portion of its substance being given off to enter into the composition of the leaf. This appearance is most evident in those cases where the internodes are clearly developed, and especially so, if under such circumstances the leaf or leaves which arise encircle the stem, as in the Bamboo and other Grasses; in these each leaf causes the formation of a hardened ring externally (*fig.* 187), and thus produces the appearance of a joint or articulation, and indeed in rare cases, the stem does readily separate into distinct portions at these joints, in which case it is said to be *jointed* or *articulated*.

Buds.—Under ordinary circumstances, as we have seen, one or more buds are developed in the axil of every leaf (*fig.* 191).

Fig. 191.

Fig. 192.

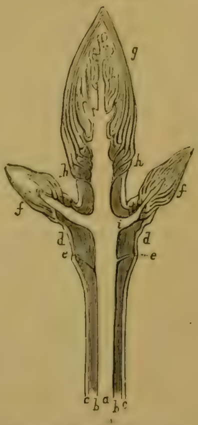


Fig. 191. Branch of Oak with alternate leaves and leaf-buds in their axils.——*Fig.* 192. Longitudinal section of the end of a twig of the Horse-chestnut (*Æsculus Hippocastanum*), before the bursting of the bud. After Schleiden. *a*. The pith. *b*. The wood. *c*. The bark. *d, d*. Scars of leaves of former years. *e, e*. The vascular bundles of those leaves. *f, f*. The axillary buds of those leaves, with their scales and the vascular bundles belonging to them. *g*. Terminal bud of the twig ending in a rudimentary flowering panicle. *h, h*. Scars formed by the falling off of the lowest scales of the bud, and above these may be seen the closed scales with their vascular bundles. *i*. Medullary mass leading from the pith into the axillary bud.

The apex of a stem again, as well as of all its divisions which are capable of further elongation, are also terminated by a similar bud. Each bud, whether lateral or terminal, is pro-

duced by an elongation of the horizontal or parenchymatous system of the stem or its divisions, and consists at first of a minute conical central cellular mass, which is connected with the pith; around this, spiral and other vessels and wood-cells are soon developed, also in connexion with similar parts of the wood, and on the outside of these, in a cellular substance which ultimately becomes the bark, we have little conical projections of parenchyma developed, which are the rudimentary leaves. As growth proceeds these parts become more evident, and a little conical body is formed at the apex of the stem, or laterally in the axil of leaves, and the formation of the bud is completed (*fig.* 192).

The buds of temperate and cold climates, which remain dormant during the winter, and which are accordingly exposed to all its rigours, have generally certain protective organs developed on their outer surfaces in the form of modified leaves, which are commonly called *scales.* These are usually of a hardened texture, and are sometimes covered with a resinous secretion, as in the Horsechestnut and several species of Poplars; or with a dense coating of soft hairs or down, as in some Willows. Such scales, therefore, by interposing between the tender rudimentary leaves of the bud and the air a thick coating of matter which is a bad conductor of heat and insoluble in water, protect them from the influence of external circumstances, by which they would be otherwise destroyed. Buds thus protected are sometimes termed *scaly.* In the buds of tropical regions, and those of herbaceous plants of temperate climates which are not thus exposed to the influence of a winter, such protective organs would be useless, and are accordingly absent, and hence all the leaves of the bud are nearly of the same character. Such buds are called *naked.* In a few instances, we find even that the buds of perennial plants growing in cold climates are naked like those of tropical plants. Such is the case with the Alder Buckthorn (*Rhamnus Frangula*), some species of Viburnum, &c.

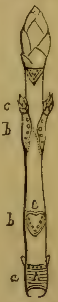
These external modified leaves, or protective organs of the bud, are commonly, as we have just mentioned, termed *scales*, but they have also received the names of *tegmenta*, *perulæ*, &c. That such scales are really only modified leaves adapted for a special purpose, is proved not only by their position with regard to the true leaves, but also from the gradual transitional states, which may be frequently traced from them to the ordinary leaves of the bud; this is very clearly exhibited in the *Æsculus Pavia.* Thus, as stated by Lindley:—" In this plant the scales on the outside are short, hard, dry, and brown; those next them are longer, greenish, and delicate; within these others become dilated, are slightly coloured pink, and occasionally bear a few imperfect leaflets at their apex; in succession are developed leaves of the ordinary character, except

that their petiole or stalk is dilated and membranous, like the inner scales of the bud; and, finally, leaves perfect in all their parts complete the series of transitions." The scales thus shown to be modified leaves may be formed either of one or of more than one of the parts of a leaf; and the bud receives different names accordingly. Thus, if the scales are formed by the lamina or flattened foliaceous part, as in *Daphne Mezereum* the bud is called *foliaceous;* if, by expansions of the base of the petiole or leaf-stalk, as in the Walnut-tree, *petiolaceous;* if by the stipules, or lateral leafy expansions of the petiole, as in the Magnolia, *stipulaceous;* if by both stipules and the petiole combined, as in the common Plum, *fulcraceous.*

As soon as the laminæ of the leaves in the bud have acquired a certain size, they become variously folded or rolled on one another, by which they adapt themselves to its rounded form and small space. This arrangement of the leaves in the bud is called *vernation* or *præfoliation.* There are various modifications of this, each of which is distinguished by a particular name. These will be described hereafter, when treating of the leaves.

The bud, as we have seen, contains all the elements of a stem or a branch (*fig.* 192); in fact, it is really the first stage in the development of such parts, the axis being here so short that the rudimentary leaves are closely packed together, and thus overlap each other (*fig.* 193). When growth commences in the spring, or whenever vegetation is reanimated, the internodes between the leaves become developed, and these therefore become separated from each other (*fig.* 194, *c*), and thus the stem increases in length, or a branch is formed. In other words, the leaves, *c*, which in a bud state overlap each other and surround a growing point or axis, by the elongation of the internodes of that axis become separated and dispersed over a branch or an elongation of the stem, much in the same way as the joints of a telescope become separated from each other by lengths of tube when it is drawn out. The branch therefore, like the bud from which it is formed, necessarily contains the same parts as the axis upon which it is placed, and these parts are also continuous with that axis, with the exception of the pith, which, although originally continuous in the bud state, ultimately becomes separated

Fig. 193. *Fig.* 194.



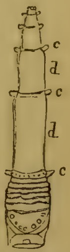


Fig. 193. A shoot one year old of the Horsechestnut, with terminal bud. *a.* Scars produced by the falling off of the bud-scales of the previous year; *b.* Scars produced by the falling off of the petioles of the leaves of the present year, with buds, *c.* in their axils.——*Fig.* 194. Diagram to illustrate the growth of the shoot from the bud. *c, c, c.* The nodes where the leaves are situated. *d, d.* The internodes developed between them.

by the development of tissue at the point where the branch springs from the axis.

From the above circumstances, it follows that a bud resembles in its functions the embryo from which growth first commenced, and it has been thus termed a *fixed embryo.* There is this difference however between them,—a bud continues the individual, while the embryo continues the species. A stem is therefore really made up of a number of similar parts or buds, called *phytons,* which are developed in succession, one upon the summit of the other. Hence, by the development of terminal buds the stem increases in height; and by those situated laterally branches are produced. A tree may thus be considered as a compound body, formed of a series of individuals which mutually assist each other, and benefit the whole mass to which they belong. In exogenous trees, which form lateral or axillary buds, the destruction of a few branches is of no consequence, as they are soon replaced; but in Palms, and most other endogenous trees, and also in those of acrogenous growth which develope only from terminal buds, the destruction of these under ordinary circumstances, as we have seen, leads to their death.

The buds or similar parts, of which a tree has thus been shown to be made up, are also capable of being separated from their parent and attached to another individual of the same, or even of one of a nearly allied species. The operations of Budding, Grafting, &c., depend for their success upon this circumstance. In some plants, buds naturally separate from their parents, and produce new individuals. These operations are of great importance in horticulture, because all plants raised by such means propagate the *individual peculiarities* of their parents, which is not the case with those raised from seed, which have merely a *specific* identity.

Ramification.—In the same way as branches are produced from buds placed on the primary axis or stem, so in like manner from the axils of the leaves other buds and branches are formed; these again will form a third series, to which will succeed a fourth, fifth, &c. In practice, the main divisions of the primary axis or stem are called branches (*rami*), while the smaller divisions of these are commonly termed twigs (*ramuli*). The general arrangement and modifications to which these are liable are commonly described under the name of *ramification.*

All lateral or axillary buds which are developed in the axil of leaves are called *regular* or *normal,* and their arrangement in such cases is necessarily the same as that of the leaves. Again, as branches are formed from buds thus placed, it should follow that their arrangement should also correspond to that of the leaves. This corresponding symmetry, however, between the arrangement of the branches and leaves is interfered with from various causes. In the first place especially, by many of *the*

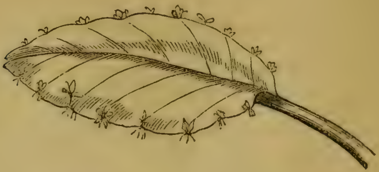
regular buds not being developed. Secondly, by the development of other buds which are not placed in the axils of leaves, but which arise irregularly at various points; these are called, from their abnormal origin, *adventitious:* and, Thirdly, by the formation of *accessory buds.*

First, as to the *non-development of the regular buds.* This frequently takes place irregularly, and is altogether owing to local or special causes; thus, want of light, too much crowding, or bad soil, may cause many buds to become abortive, or to perish after having acquired a slight development. In other instances, however, this non-development of the buds takes place in the most regular manner; thus, in Firs where the leaves are very closely arranged in a spiral manner, the branches, instead of presenting a similar arrangement, are placed in circles or rings round the axis, at distant intervals. This arises from the non-development of many of the buds of the leaves forming a spire, which is followed by the development of the buds in the axils of other leaves successively, and as such leaves are thickly placed, we are unable, after the development of the branches, to trace clearly the turns of the spire, so that they appear to grow in a circle. Many other instances might be adduced of the influence of the non-development of the regular buds, but the above will be sufficient for our purpose.

2. *Adventitious Buds.*—These have been found on various parts of the plant, as on the root, to be afterwards referred to, the woody part of the stem, the leaves, &c. Thus, when a tree is *pollarded,* that is when the main branches on the apex of the stem are cut off, the latter becomes gorged with sap, and a multitude of adventitious buds are formed from which branches are produced. The branches thus produced by pollarding, are, however, to a certain extent caused by the development of other regular buds which had become latent from some of the causes already alluded to as interfering with their non-development. In every instance the adventitious buds take their origin from parenchymatous tissue: thus, if produced on the stem or branches, it is from the ends of the medullary rays; when developed upon leaves, they may arise from their borders as in *Malaxis paludosa* (*fig.* 196) and *Bryophyllum calycinum* (*fig.* 195), or from their surface as in *Ornithogalum thyrsoideum* (*fig.* 197). Leaves thus bearing buds are called *proliferous.* Such buds are naturally formed on the leaves of the above plants, and occasionally on others, but they may be also produced artificially on various leaves, such as those of *Gesnera*, *Gloxinia*, and *Achimenes*, by the infliction of wounds, and then placing them in a moist soil and exposing them to the other influences which are favourable for their growth. The buds developed on the leaves in such cases ultimately form independent plants, and this method is constantly resorted to by gardeners as a means of propagation. It would appear that

in all cases where the parenchyma near the surface of a plant has its vitality excited, or when an accumulation of nutritive

Fig. 195.



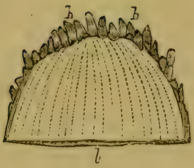


Fig. 196.

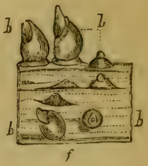


Fig. 197.

Fig. 195. Leaf of *Bryophyllum calycinum* with buds on its margin.——*Fig.* 196. End of the leaf, *l*, of *Malaxis paludosa*, with buds, *b*, *b*, on its margin.——*Fig.* 197. A portion of the leaf, *f*, of *Ornithogalum thyrsoideum*, showing buds, *b*, *b*, *b*, on its surface.

matter takes place, it is capable of taking up an independent development, and forming *adventitious buds.* These buds differ however from those commonly produced in the axil of leaves, or at least from those which remain dormant during the winter; thus they are smaller, and have no external protective organs or scales.

Fig. 198.

Fig. 199.

Fig. 198. Embryo-bud or nodule of the Cedar.——*Fig.* 199. A vertical section of the same surrounded by the bark.

Embryo-Buds.—In some trees these adventitious buds, instead of being developed on the outside of the stem, are enclosed in the bark. Such have been called *embryo-buds* or *nodules.* They may be readily observed in the bark of certain trees, such as the Cork-oak, the Beech, the Cedar of Lebanon, &c., in which they produce externally little swellings, which, when examined, are found to be owing to the presence of these nodules, which have a

more or less irregular ovoid or spheroidal form (*fig.* 198), and woody texture. Upon making a transverse section of one of them (*fig.* 199) we observe a central pith surrounded by concentric zones of wood (the number of which varies according to its age as in ordinary trees) and traversed by medullary rays; in fact, as stated by Dutrochet, it has all the elements of organization found in the trunk of a tree. In the course of their development these embryo-buds frequently reach the wood, with the growth of which they become confounded and thus form what are called ***knobs.*** In other cases a number of nodules meeting together on the surface form an *excrescence.* That such nodules are analogous to buds is proved by the fact of their sometimes producing a short branch from their summits, as in the Cedar of Lebanon and in the Olive. Those of the latter plant, under the name of *Uovili*, are really employed for its propagation. Lindley also states that he has a number of these nodules which he received from Prince of Wales' Island, which exhibit all sorts of transitions, from their common irregular spheroidal form to modified branches. Hence there can be no doubt of their analogy to buds. The peculiar appearance of the wood of the Bird's-eye Maple is said to be caused by the presence in it of these nodules.

3. *Accessory Buds.*—The third cause of irregularity in the distribution of branches arises from the multiplication of buds in

Fig. 200.

Fig. 201.

Fig. 202.

Fig. 200. Branch of a species of Maple with three buds, *a*, placed by the side of one another.——*Fig.* 201. A piece of the branch of the Walnut-tree. *p.* The petiole having in its axil a number of buds, *b*, placed one above the other, the uppermost most developed.——*Fig.* 202. A piece of the branch of the Tartarian Honeysuckle (*Lonicera tartarica*), bearing a leaf with numerous buds in its axil placed above one another, the lowermost being the most developed.

the axils of leaves. Thus, instead of one bud, we have in rare cases two, three, or more thus situated, such are called *accessory*

buds. Such buds may be either placed one above the other, or side by side. Thus, in certain Willows, Poplars, and in Maples, &c., we have three buds placed side by side (*fig.* 200), which frequently give rise to a corresponding number of branches. In some Aristolochias, in Walnuts (*fig.* 201), in the Tartarian Honeysuckle (*fig.* 202), and other plants, the accessory buds are arranged one above the other. Sometimes the uppermost bud alone developes, as in the Walnut, and thus the branch which is formed arises above the axil of the leaf, in which case it is said to be *extra-axillary*. In the Tartarian Honeysuckle the axillary or lowest bud is that which forms the strongest branch, over which a number of smaller branches are placed, arising from the development of the accessory buds. In some trees such as the Fir, Ash, &c., these accessory buds, instead of forming separate branches, become more or less united, and assume a flattened or thickened appearance. Such branches are commonly called *fasciated.* These branches may however be produced by a single bud developing in an irregular manner.

Besides the above three principal sources of irregular development of the branches, other minor ones arise from the formation of *extra-axillary* branches in other ways than those just alluded to. Thus the stem may adhere to the lower part of the branch, which thus appears to arise from above the axil of the leaf; or to the petiole or leaf-stalk, when it appears to arise from below it. Other irregularities also occur, but they are of little importance compared to those already mentioned, and need not therefore be further treated of.

3. Of the Forms and Kinds of Stems and Branches.—In form the stem is usually more or less cylindrical, in other cases it becomes angular, and in some plants, particularly in certain classes, it assumes a variety of anomalous shapes. Thus in many Orchids it becomes more or less oval or rounded, and has received the name of *Pseudobulb;* in the Melon-Cactus, globular; in other Cacti, columnar, more or less flattened, or jointed. In the Tortoise or Elephant's-foot Plant it forms a large rough irregular mass.

In general stems possess a firm texture, and can therefore readily sustain themselves in an upright direction; at other times they are too weak to support themselves, and thus require the aid of some other body. In such cases, if they trail on the ground, they are *procumbent* or *prostrate;* if when thus reclining they rise towards their extremity, they are *decumbent;* or if they rise obliquely from near the base, *ascending.* Some weak stems, instead of resting on the ground, take an erect position and cling to neighbouring objects for support. Such are called *climbing* or *scandent* if they proceed in a more or less rectilineal direction, as in the Passion-flower (*fig.* 209), where they cling to other bodies by means of little twisted ramifications called

tendrils; or in Ivy, where they emit little root-like processes from their sides, by which they adhere to neighbouring bodies (*fig.* 203). If such stems twist round other bodies in a spiral

Fig. 203.

Fig. 203.
Climbing stem of the Ivy.

Fig. 204.

Fig. 204. Stem of Honeysuckle.

Fig. 205.

Fig. 205.
Stem of Convolvulus.

manner they are said to be *twining;* and this may take place either from right to left, as in some Convolvuli (*fig.* 205), in the French Bean, and Dodder; or from left to right, as in the Honeysuckle (*fig.* 204), Hop, and Black Bryony; or first in one direction and then in another, irregularly, as in the White Bryony. These climbing and twining plants are generally herbaceous or die annually when growing in cold and temperate regions, although we have exceptions to this in the Vine, Clematis, and Honeysuckle which have woody stems; in which case such a stem has received the name of *sarmentum.* In tropical climates these woody creeping or twining stems often occur; they are called *lianas*, and these frequently ascend to the tops of the loftiest trees, and then either descend to the ground again, or run to the branches of neighbouring trees.

The stem has received many names according to its nature. Thus it is called a *caulis* in plants which are herbaceous, or die

down annually; a *trunk* as in trees, where it is woody and permanent; a *culm* as in most Grasses and Sedges, where it presents a jointed appearance; and a *caudex* or *stipe* as in Tree-Ferns and Palms. The term caudex is also frequently applied to any woody erect or ascending root-like forms of stems, and is thus sometimes nearly allied to the rhizome. (See p. 113.)

From the nature, duration, and mode of ramification of their stems, plants have been divided from the earliest periods into three classes, called respectively, *Herbs*, *Shrubs*, and *Trees.* Thus, all plants are called *herbs* which have stems that die down annually to the surface of the ground; while those which form permanent aerial woody stems are denominated *trees* or *shrubs*, according to circumstances. Thus, the term tree is applied if the branches are permanent and arise from a trunk; if the tree is of small size, the term *arbusculus* is used. The collection of branches which arise from the trunk and form the head of a tree is called the *coma*, or improperly *cyma* by some botanists. When the branches are permanent and proceed directly from, or near to the surface of the ground, without any trunk, or where this is very short, a *shrub* is formed. This when low and branched very much at the base, is denominated a *bush.* The term *undershrub* is also applied to a small shrub which is intermediate in its characters between an ordinary shrub and an herb, thus, some of its branches frequently perish annually, while others are more or less permanent. All the above kinds of stems are connected by various intermediate links, so that in many cases they are by no means well defined.

If the terminal bud of a stem is continually developed, the axis upon which it is placed is prolonged upwards from the earth to its summit, giving off from its side the lateral branches, as in most Firs. Such a stem has been termed an *excurrent stem.* When the main stem is arrested in its development by the process of flowering, or some other cause, and the lateral buds become the more vigorously developed, so that the stem appears to divide into a number of irregular branches, it is said to be *deliquescent.* These different kinds of growth influence materially the general form of trees. Thus, those with excurrent stems are usually more or less conical or pyramidal. Those with deliquescent stems are rounded or spreading. The general appearance of trees also depends upon the nature of the lateral branches, and upon the angle which they make with the stem from which they arise. Thus, if the branches are firm, and arise at an acute angle to the stem, as in the Cypress and Lombardy Poplar, they are erect, and the tree is more or less narrowed; if they come off at a right angle, the branches are *spreading* or *patent*, as in the Oak and Cedar; if the angle is very obtuse, or if the branches bend downwards from their origin, as in the Weeping Ash and Weeping Elm, they are termed *weeping* or *pen-*

dulous; in other cases this weeping appearance arises from the weakness and flexibility of the branches, as in the Weeping Willow and Weeping Birch. The relative length also of the upper and lower branches will give rise to corresponding differences in the general appearance of trees. Thus, if the lower branches are the longest and become shorter as they approach the top, the whole will be shaped like a cone or pyramid, as in the Spruce Fir; if the middle branches are longer than those of the base and apex, the general appearance will be rounded or oval, as in the Horsechestnut; if those of the top are the most developed, the form will be umbrella-like, as in the Italian Pine (*Pinus Pinea*). The above are the extreme forms only, between which, as may be readily supposed, there are a number of intermediate ones.

Besides the forms of stems and branches already described, there are some others which have received special names. These we now proceed to notice.

Spines or Thorns.—It sometimes happens that a leaf-bud instead of developing as usual, and forming an ordinary branch with leaves on its surface, becomes arrested in its growth, and forms a hardened projection terminating in a more or less acute point, as in Thorns (*fig.* 207), Gleditschia (*fig.* 206),

Fig. 206.

Fig. 207.

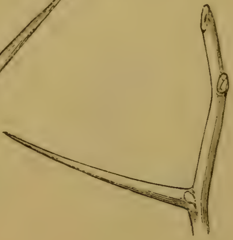


Fig. 206. Branching spine of the Honey Locust (*Gleditschia*).
Fig. 207. Spine of a species of Thorn.

&c. Such an irregularly-developed branch is called a *spine* or *thorn*. That the spines are really modified branches is proved not only by their structure, containing as they do all the elements of the stem or branch upon which they are placed; but also by their position in the axils of leaves; by their some-

Fig. 208.

Fig. 208. Leafy spines of the common Sloe.

times bearing leaves, as in the Sloe (*fig.* 208), and Spiny Rest-harrow; and by their being frequently changed into ordinary branches by cultivation. Thus, the Apple and Pear in their wild state are commonly spiny, but when cultivated they are spineless. The spines are sometimes confounded by the young observer with prickles already described (see p. 49), but they are readily distinguished from these by their structure and intimate connexion with the internal parts of the stem; the prickles being merely formed of hardened parenchyma, arising immediately from and in connexion only with the bark.

Tendril or Cirrhus.—This term is applied to a thread-like leafless branch, which is twisted in a spiral direction, as in the Passion-flower (*fig.* 209). It is one of those contrivances of nature by means of which weak plants are enabled to rise into the air by attaching themselves to neighbouring bodies for support. Tendrils are also observed in the Vine (*fig.* 210),

Fig. 209.

Fig. 210.

Fig. 209. A portion of the stem of *Passiflora quadrangularis.* — *Fig.* 210. Part of the stem of the Vine. *v, v, v.* Tendrils.

where they are regarded by many botanists as the terminations of separate axes, or as transformed terminal buds. Both spines and tendrils are sometimes produced from leaves and other

parts of the plant ; these will be referred to hereafter, under the heads of the organs of which they are respectively modifications.

KINDS OF STEMS.—We have seen that the stem, when first developed, always takes a diametrically opposite direction to that of the root. In many instances this direction is continued more or less throughout its life. In other plants, however, the terminal bud either acquires an irregular direction, and the stem runs along, or remains under, the surface of the ground; or it perishes altogether at a very early period, and an axillary branch will take its place, and this also, by developing laterally, will likewise continue near the surface of the ground, or burrow beneath it. From these peculiarities in the direction and growth of stems and branches, we have a number of modifications which we have now to describe. These are best treated of under two heads, namely, those which are *aerial*, and those which are *subterranean*. We can, however, by no means draw a distinct line between the modifications of stem which these two divisions respectively contain, as certain forms occasionally pass from one into the other, thus being both subterranean and aerial at different points, or at different periods.

1. *Aerial Modifications of the Stem.*—Of these we shall describe the *runner*, the *offset*, the *stolon*, the *sucker*, and the *rhizome*.

a. *The Runner.* (*Fig.* 211.)—This is an elongated slender prostrate branch, sent off from the base of the stem, and giving off at its extremity roots and leaves ; thus producing a new plant,

Fig. 211.

Fig. 211. A portion of the common Strawberry plant. *a′*. An axis producing a tuft of leaves, *r*, at its extremity, from the axil of one of which another axis or runner, *a″*, arises, bearing a rudimentary leaf, *f*, near the middle, and a cluster of leaves, *r*, at its end. *a*. A third axis produced in a similar manner to the former.

which extends itself in a similar manner. It is well seen in the common Strawberry and Potentilla. The runner is sometimes known under the name of the *flagellum*, hence such branches are termed *flagelliform*.

b. *The Offset.* (*Fig.* 212.)—This is a short, prostrate, more or less thickened branch, which produces at its apex roots and a tuft of leaves, and thus forms an independent plant, which is capable of producing other offsets. It is seen in the Houseleek. It differs very little from the ordinary runner, except in being shorter and somewhat thicker.

Fig. 212.

Fig. 212. The offset of *Sempervivum.*

c. *The Stolon.*—This is a branch given off above the surface of the ground, but which curves or proceeds downwards towards it, and when it reaches a moist spot it produces a root and an ascending stem, and being thus capable of acquiring nourishment independently of its parent it ultimately forms a new individual. The Currant, Gooseberry, and other plants, multiply in this way. All such plants are said to be *stoloniferous.* Gardeners imitate this natural formation of new individuals, when they lay down a branch into the earth, from which a new plant is ultimately formed. This process is technically called *layering* (*fig.* 213).

Fig. 213.

Fig. 213. Plant, showing the process of *layering.*

d. *The Sucker* (*Figs.* 214 and 215.)—This is a branch which arises from the stem below the surface of the earth, and which after proceeding in a horizontal direction for a certain distance, and giving off roots in its course, turns upwards into the air, and ultimately forms an independent plant, as in the former instances. Plants thus producing suckers are said to be *surculose.* Good examples of this form of stem are seen in the Rose, the Raspberry, the Mint (*fig.* 215), &c. The sucker can scarcely be said to differ in any essential particulars from the stolon, except that it is originally subterranean, and ultimately becomes aerial, while the stolon is first aerial and then subterranean. This form of stem is an illustration of the impossibility of drawing any distinct line of demarcation between aerial and subterranean stems, as it is both at different parts of its course, and hence might be placed in either division.

Fig. 214.

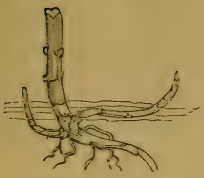
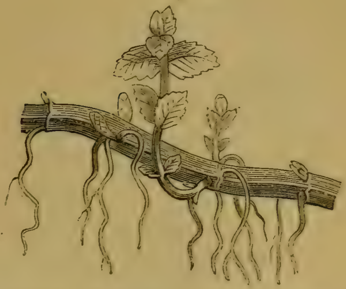


Fig. 215.



Figs. 214 and 215. Suckers of a species of Mint, &c.

e. *The Rhizome or Rootstock.* (*Figs.* 216 and 217.) — This is a prostrate thickened stem or branch running along the surface

Fig. 216.

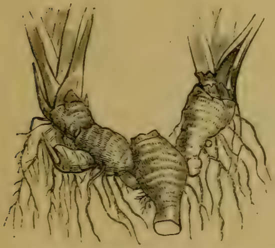


Fig. 217.

Fig. 216. A portion of the rhizome of a species of Iris. —— *Fig.* 217. A portion of the rhizome of the Solomon's Seal (*Polygonatum multiflorum*). *b.* A branch. *b′.* Bud. *c, c.* Scars produced by the decay of old branches.

of the ground, or more generally partly beneath it, and which gives off roots from its lower side, and buds from its upper. Such stems sometimes creep for a long distance in this way, and have the upper surface marked by scars (*fig.* 217, *c*), which are produced by the falling off of their leaves or herbaceous stems. Such a form of stem is presented by the Iris, Sweet-flag, the Ginger, Solomon's Seal, &c. The name rhizome is applied by many botanists to all stems of this nature and appearance whether aerial or subterranean. It forms, therefore, a natural transition to the latter kinds of stems; which we now proceed to describe,

2. *Subterranean Modifications of the Stem.* — All these were formerly confounded with roots, and they are still in common

language thus designated. They are distinguished from roots, however, either by the presence of leaves and buds, or by scales or modified leaves, or by the presence of scars on their surface, which have been produced by the falling off of former leaves or buds. They have thus a provision for regular ramification, which is not the case with roots. The different forms of aerial stems described above, when partially subterranean, may be also distinguished in a similar manner from roots.

a. *The Creeping Stem.* (*Fig.* 218.)—This form of stem is also

Fig. 218.

Fig. 218. Creeping stem of the Sand Carex (*Carex arenaria*). 1. Terminal bud by which the stem continues to elongate. 2, 3, 4. Shoots produced from former buds.

called a *Soboles*, and popularly a *creeping-root*. It is a slender branch which runs along beneath the surface of the earth, emitting roots from its lower side, and buds from its upper, in the same manner as the rhizome, and it is considered by many botanists as a variety of that stem. The only differences existing between the creeping stem as defined above and the rhizome are its more slender form and entirely subterranean course. The Sand Sedge or Carex (*Carex arenaria*), the Couch Grass (*Triticum repens*), &c., afford good examples. In some instances such stems serve important purposes in nature; thus those of the Sand Sedge, by spreading through the sand of the sea-shore, bind it together and prevent it from being washed away by the waves. Others, like those of the Couch Grass, are the pest of the agriculturist, who finds it very difficult to destroy them by cutting them into pieces, for as every node is capable of developing a bud and roots, each piece into which they will then be divided is capable of becoming an independent individual, and therefore such an operation only serves the purpose of multiplying such stems by placing the separated parts under more favourable circumstances for development.

b. *The Tuber.* (*Figs.* 219 and 220.)—This is a subterranean branch, arrested in its growth, and excessively enlarged by the deposition of starch and other nutritious substances in its tissue. It has upon its surface a number of little buds, or eyes as they are commonly called, from which new plants are formed the

Fig. 219.

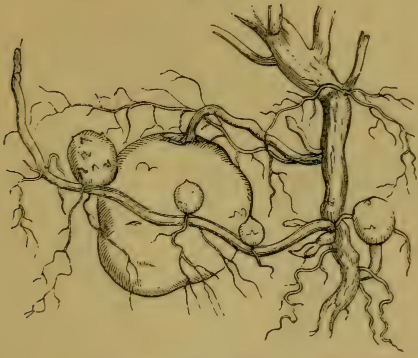


Fig. 219. Tubers of the common Potato (*Solanum tuberosum*).

succeeding year. The possession of these buds indicates its nature as a kind of stem. The Potato (*fig.* 219) and Jeru-

Fig. 220. *Fig.* 221.

Fig. 220. Tubers of the Jerusalem Artichoke (*Helianthus tuberosus*). —— *Fig.* 221. A monstrous branch or bud of the common Potato. From *The Gardener's Chronicle.*

salem Artichoke (*fig.* 220) are good illustrations. A case was reported in the "Gardener's Chronicle" of a Potato plant in which the buds in the axils of the true leaves above ground showed a tendency to form tubers (*fig.* 221), by which

their analogy to stems was clearly indicated; this is also corroborated by the common experience of gardeners, who, by surrounding the lower part of the stems of the potato with earth, increase the number of tubers by converting the buried buds (which under the usual circumstances would have produced ordinary branches) into those organs.

Fig. 222.

Fig. 222. Bulb of Lily. *a*. Shortened axis or plate. *p*. Flowering-stem. *c*. Lateral buds or cloves.

c. *The Bulb.*—This is a shortened, usually subterranean stem or branch, generally in the form of a rounded or flattened plate (*fig.* 222), which bears on its surface a number of fleshy scales or modified leaves; or it may be considered as a subterranean bud of a scaly nature, which sends off roots from below, and from its centre upwards a stem with foliage and flowers. The scales are generally more or less thickened by deposition of nutritive matters; these, therefore, serve as reservoirs of nutriment for the future use of the plant, just as in other cases the enlarged stems serve a similar purpose. The bulb is only found in Monocotyledonous Plants, as in the Lily (*figs.* 222, 223, and 224), Onion (*fig.* 225), Tulip, &c. The scales of a bulb,

Fig. 223.

Fig. 224.

Figs. 223 and 224. Scaly bulbs of the Lily. *a*, *a*. Shortened axis. *b*, *b*. Roots. *d*, *d*. Flowering stem. *c*, *c*. Scales.

like the ordinary leaves of a branch, have the power of developing in their axils new bulbs (*fig.* 222, *c*), called by gardeners *cloves*, which circumstance is an additional proof of the analogy of a bulb to a branch or bud. There are two kinds of bulbs commonly distinguished by botanists, namely the *tunicated* (*fig.* 225), and the *scaly* (*fig.* 224). The *tunicated bulb* is well seen in the

Onion and other species of the same genus, as also in the Squill, &c. In these, the inner scales which are thick and fleshy and enclose each other in a concentric manner are covered externally by thin and membranous ones, which form a covering or *tunic* to them, and hence the name *tunicated* or *coated.* In the *scaly.* or *naked* bulb as it is also called, as in the Lily (*fig.* 223 and 224), the whole of the scales of which it is composed are thick and fleshy, and overlap each other like the component leaves of an ordinary bud.

Fig. 225.

Fig. 226.

Fig. 225. Tunicated bulb of the Onion. —— Fig. 226. Stem of a species of Lily (*Lilium bulbiferum*), bearing bulbils or bulblets, *a, a*, in the axils of its leaves.

In the axils of the leaves of some plants, such as certain species of Lily (*fig.* 226), the Coralwort (*Dentaria bulbifera*), Pilewort (*Ranunculus Ficaria*), &c., small conical or rounded bodies are produced, which are of the nature of bulbs, and are hence called *Aerial bulbs* or *bulbils* or *bulblets.* They differ from the ordinary buds by their fleshy nature, and in spontaneously separating from their parent, and producing new individuals when placed under favourable circumstances.

The young bulbs which are developed in the axils of the scales or leaves of subterranean bulbs either remain attached to their parent, which they commonly destroy by absorbing all its stored up nutriment; or they become separated in the course of growth, and form independent plants

d. *The Corm.*—This form of stem, like the bulb, is only found in Monocotyledonous Plants, as in the Colchicum (*fig.* 229), Crocus (*figs.* 227 and 228), Gladiolus, &c. It is an enlarged,

solid, subterranean stem, of a rounded or oval figure, and commonly covered externally by thin scales. By Lindley it is

Fig. 227.

Fig. 228.

Fig. 227. Corms of *Crocus sativus.* *a*, *b*. The new corms, arising from *c*, the apex of the old or parent corm.——*Fig.* 228. Section of the former.

defined "as the dilated base of the stem of Monocotyledonous Plants, intervening between the roots and the first buds." By some botanists it is considered as a kind of bulb, in which the stem or axis is much enlarged, and the scales reduced to thin membranes. Practically a corm may be distinguished from a bulb by its being solid, whereas a bulb is formed of imbricated scales. The corm is known to be a form of stem by producing from its surface one or more buds, as in the Crocus (*figs.* 227 and 228), where they proceed from the apex, and ultimately destroy their parent by feeding upon its accumulated nutriment. These new corms, in a future year, also produce others near their apex, which by developing at the expense of their parents destroy them in like manner, and these again form other corms by which they are themselves destroyed. In this manner the new corms, as they are successively developed, come gradually nearer and nearer to the surface of the earth. In the Colchicum (*fig.* 229), the new corm is developed on one side of the old, near its base. This feeds upon its parent, and ultimately destroys it, and is in like manner destroyed the next year by its own progeny. Thus, in taking up such a corm carefully, we find (*fig.* 229), *a*, the shrivelled corm of last year; *a''*, that of the present season, which, if cut vertically, shows *a'''*, the corm, in a young condition for the next year. All corms contain starch or other nutritious matters, which are stored up for the future use of their offspring.

Fig. 229.

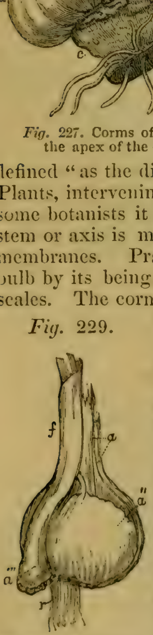


Fig. 229. Colchicum. *r.* Roots. *f.* Leaf. *a.* Shrivelled remains of last year's corm. *a''.* Corm of the present year. *a'''.* Commencement of the corm of next year.

Section 2. The Root or Descending Axis.

The root may be defined as that portion of the axis which passes at its first development in an opposite direction to the stem, avoiding the light, fixing the plant to the soil, or to the substance upon which it grows, or floating in the water when the plant swims upon the surface of that medium, and deriving nourishment for it. The part where the stem and root diverge has been called the *neck* or *collum*, or formerly, the *vital node*, because it was erroneously supposed to be the seat of the life of the plant. The term *coarcture* has been also applied to the same point, from the axis being there generally more or less contracted, at least in the young plant; but, as it continues to develope all traces externally of this point are usually destroyed, so that after a few years it becomes very difficult, if not impossible, to discover its position. That part of the root which joins the stem is called the *base*, the opposite extremity the apex. Having so fully described the structure and general characters of the stem, it will be unnecessary for us to dwell further upon the root than to indicate especially those points where it presents any distinctive appearances.

Roots may be divided into two classes, namely, *True* or *Primary*, and *Adventitious* or *Secondary*. Our remarks up to the present time apply more particularly to the former, to which we shall also at present continue to direct our attention.

1. True or Primary Root.—This is formed at first by additions made within the extremity of the radicle of the embryo; and the mode in which it takes place may be thus stated:—Growth commences by the multiplication of cells by division, just within the apex of the radicle (*fig.* 230, *a*); these cells then elongate by their own inherent vitality, by which the tissue constituting the apex *b* is pushed onwards, and gradually perishes, or is thrown off; the innermost of these newly formed cells then remain unaltered, while others immediately within the point of the root continue to multiply by division and grow in a similar manner to the former, by which a layer of tissue at the apex is again pushed forward and perishes in like manner; then new growth commences within this as in the former instance, to be followed by similar changes; so that additions are always made at first just within the extremity of the root, and not directly at its extremity, as is often stated, and as new tissue is developed it is gradually destroyed. Thus, the apex of the root is always clothed by a layer of denser tissue than that which is be-

Fig. 230.

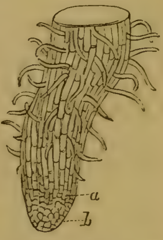


Fig. 230. Young root of a Maple magnified. *a.* The part where growth is taking place. *b.* The original extremity. After Gray.

neath it. Roots do not grow therefore, throughout their entire length like stems, but only at their extremities, which are continually pushed forward and renewed. Every division of a root also elongates in a similar manner. Roots increase however, in diameter, in the same manner as stems.

The points of the root were formerly considered to be special organs, and called *spongioles* or *spongelets* (*fig.* 231, *sp*), from

Fig. 231.

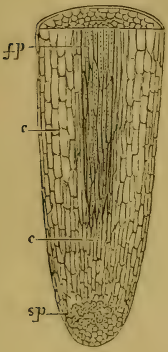


Fig. 232.

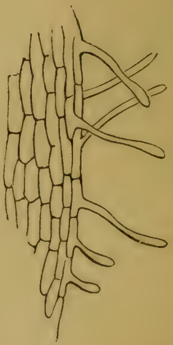


Fig. 231. Highly magnified vertical section of an Orchis root. *sp.* Spongiole. *c, c.* Parenchymatous cells. *fp.* Wood-cells and vessels.——*Fig.* 232. Fibrils or root-hairs on the surface of a young root.

the idea that they absorbed fluid for the use of the plant, in the same manner as a sponge sucks up water. But it will be seen from the above description of the growth of roots, that such ideas are entirely erroneous, for there are no special organs or spongioles situated at the extremities of the root, but that these are only the denser layers of tissue which are gradually pushed onwards by the development which is taking place within them, and as they decay they are replaced by others. It is also quite evident that absorption cannot take place to any great extent, at least, through this old and dense tissue.

At first the elongating growing extremities of the root consist entirely of parenchymatous cells ; wood-cells and vessels however soon make their appearance, and are constantly added to below by the new tissue formed as the root continues to lengthen (*fig.* 231, *fp*). When the root is fully developed, these vessels and wood-cells generally form a central mass or wood, in which there is commonly no pith, and no medullary sheath. But externally there is a true bark, which is also covered when

young by a modified epidermis without stomata, which, as we have seen, is sometimes called epiblema (p. 41). This epiblema, in the process of development, is also furnished with hair-like prolongations, which are commonly termed *fibrils* or *fibrillæ* (*fig.* 232). This term fibril is, however, applied by Lindley and some other botanists to the minute subdivisions of the root. These fibrils (which appear to be actively engaged in the process of absorption, as will be afterwards seen) are especially evident upon young growing roots, and as these advance in age they perish, while the tissue from which they were prolonged at the same time becomes harder and firmer, so as to form a more or less impermeable layer of cells.

Roots have no leaves, and usually no buds, hence they have as we have seen no provision for regular ramification, but they appear to divide and subdivide according to circumstances, without any order; while the branches of the stem have a more or less symmetrical arrangement as already described.

The branches of the root are thus merely repetitions of the original axis from which they are developed, and grow in a similar manner, and like it, are commonly furnished with no other organs, — such as buds and leaves for instance, as is the case with those of the stem. To this, however, there are many exceptions, for although the root has no power of forming regular buds, yet adventitious buds may be formed upon its surface, in the same manner as we have seen that under certain circumstances they may be produced from any parenchymatous tissue. The power which the root thus possesses of forming adventitious buds may be observed in the Plum-tree, the *Pyrus japonica*, the Moutan Pæony, the Japan Anemone (*Anemone japonica*), and many others. The latter plant exhibits this tendency to a remarkable extent. Thus, if the root be observed after flowering, it will be found to be covered with a number of little white conical projections, which are buds in a rudimentary condition; so that it may be then divided into a number of pieces, each of which will give rise to a new plant if placed under favourable circumstances. Again, if the trunk of a young vigorous Poplar or Apple-tree be cut across near its base, at certain seasons when vegetation is active, the roots near the surface will produce buds, from which branches will be ultimately formed.

From the above general description which has been given of the growth and structure of the root, we find that the chief distinctive characters between it and the stem may be summed up as follows: — 1st, Its tendency at its first formation to develope in an opposite direction to the stem, and thus withdraw from the light. 2nd, The root does not grow throughout the entire length of its newly formed parts like a stem, but only by additions near its apex. 3rd, The root of Dicotyledonous Plants under ordinary circumstances has no

pith or medullary sheath. 4th, It has no true epidermis with stomata, but in place of this an integument composed of cells without stomata, to which the name of epiblema has been given. 5th, It has no leaves, or scales which are modified leaves. 6th, It has no regular buds, and has consequently, no provision for a regular ramification.

2. Adventitious or Secondary Root.—This name is applied to all roots which are not produced by the direct elongation of the radicle of the embryo; because these, instead of proceeding from a definite point as is the case with the true or primary root, are to a certain extent at least accidental in their origin, and dependent upon favourable external circumstances. The branches of a true root are of this nature; as are also all those produced from the different modifications which stems assume, as the rhizome, the runner, sucker, stolon, corm, bulb, &c.; those of slips and cuttings of plants, &c.; and those of all Monocotyledonous and Acotyledonous Plants. All the above are examples of adventitious roots which are developed from parts in contact with the ground, as the stem does not commonly produce roots under other conditions. There are, however, various exceptions to this, as is the case with all those roots which are developed from plants in the air, and which are accordingly called Aerial Roots. These adventitious or secondary roots have their origin in the bark, some of the cells of which near to the vascular bundles acquire a special development, and separating from those around them, grow in the manner already described, and thus break their way through the bark, and become free.

Fig. 233.

Fig. 233. Lower part of the stem and root of the common Stock. *r.* The tap-root with its branches. *c.* The neck or point of union between stem and root. *t.* The stem. *f, f.* Leaves. *b, b.* Buds.

The true or primary root, from its being formed by a direct elongation of the radicle, generally continues to grow downwards for some time at least, and hence forms a main trunk or axis from which the branches are given off (*fig.* 233). Such a root is termed a *tap-root*, and may be commonly observed in Dicotyledonous Plants. On the contrary, those of Monocotyledonous and Acotyledonous Plants, which are adventitious or secondary, are usually of nearly equal size, and given off in clusters from the radicle (*fig.* 742). Some adventitious roots, such as those called aerial, require a more particular notice.

Fig. 234.

Fig. 234. The Banyan Tree (*Ficus indica*).

Aerial Roots.—The simplest forms of such roots are seen in the Ivy (*fig.* 203) and some other climbers. In these plants they are simply intended for mechanical support, and not to obtain nourishment for them : this they obtain by their ordinary roots fixed in the soil. In other plants, however, the aerial roots which are given off by the stems or branches descend to the ground, and fixing themselves there, not only act as mechanical supports, but also assist the true root in obtaining nourishment. Such roots are well seen in the Screw-pine (*Pandanus odoratissimus*) (*fig.* 178, 2.) in the Banyan or Indian Fig-tree (*Ficus indica*) (*fig.* 234), in the Mangrove tree (*Rhizophora Mangle*) (*fig.* 235), &c. In the latter tree these aerial roots frequently form the entire support of the stem in

Fig. 235.

Fig. 235. The Mangrove Tree (*Rhizophora Mangle*).

Fig. 236.

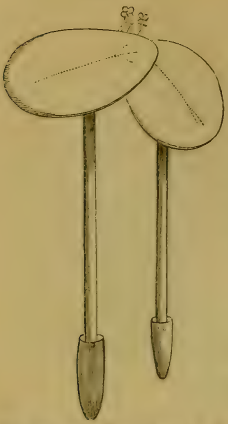


Fig. 236. Magnified plants of the Lesser Duckweed (*Lemna minor*), with the roots covered by a sheath.

consequence of this decaying at its lower part.

In the Screw-pine the extremities of these roots, while still suspended in the air, are sometimes provided with a little cap-like covering derived from the parenchyma of the bark, which they appear to have pushed before them in the course of their passage through it. Such cap-like coverings may be also seen occasionally upon the extremities of other adventitious roots. This calyptra is considered by many to be of a different nature to that which occurs on the extremities of some other adventitious roots which grow in water, as those of the Duckweed (*fig.* 236), Pistia, and some other allied plants. The latter is called the *pileorhiza,* and consists of a cellular layer which has separated entirely from the tissue of the root beneath, except at its extreme point, where it is in direct connexion with it. This cap remains under natural circumstances throughout the life of the root, which at once perishes if it be destroyed.

Fig. 237.

Fig. 237. Orchideous Plants, to show their mode of growth.

Epiphytes or Air-plants.—In these plants none but aerial roots are produced, and as these never reach the soil they cannot

obtain any nourishment from it, but must draw their food entirely from the air in which they are developed, hence the name of *air-plants* which is applied to them. They are also called *epiphytes* because they commonly grow upon other plants. Most Orchids (*fig.* 237) and Tillandsias afford us illustrations of epiphytical plants. The roots of such plants are commonly green, and possess a true epidermis and stomata ; in such particulars therefore, aerial roots also present exceptions to what is commonly observed in other roots. The roots of most Orchids have also a layer of usually very delicate cells filled with air over the true epidermis, to which the name of *root sheath* (*velamen radicum*) has been applied by Schleiden, who also calls such roots *coated roots.*

Besides these epiphytical plants there is another curious class of plants which also grow upon others, which are called *parasites.*

Parasites.—These are plants which not only grow upon others, but which, instead of sending their roots into the air and deriving their nourishment from it, as is the case with the epiphytes, send them into the tissues of the plants upon which they are growing, and obtain their nourishment from them. The Mistletoe (*Viscum album*), Broom-rapes (*Orobanche*), Dodders (*Cuscuta*) (*fig.* 238), *Rafflesia Arnoldi* (*fig* 239), may be cited as examples of such plants. These parasites are of various natures ; thus some have green foliage, as in the Mistletoe, &c.; while others are pale, or possess other tints than green, as the Broom-rapes, Rafflesia, &c. The latter plant is especially interesting as it produces the largest flowers of any known plant: thus the first flower that was discovered measured nine feet in circumference, and weighed fifteen pounds.

Fig. 238.

Fig. 239.

Fig. 238. Cuscuta or Dodder Plant.——*Fig.* 239. Flower and bud of *Rafflesia Arnoldi,* a parasitic plant of Sumatra.

Parasitical plants also vary in the degree of their parasitism; thus the Mistletoe and the greater number are entirely dependent upon the plants on which they grow for their nourishment; while others, as the Dodder, obtain their food at first by means of the

ordinary roots contained in the soil, but after having arrived at a certain age these perish, and they then derive it entirely from the plants upon which they grow ; others again continue throughout their life to derive a portion of their nourishment by means of roots imbedded in the soil.

We have now described the general characters and structure of the *true* or *primary root*, and the *secondary* or *adventitious root.* We have in the next place to allude to certain differences which roots present which are dependent upon their duration. Roots are thus divided into *annual*, *biennial*, and *perennial.*

1. Annual Roots.—These are produced by plants which grow from seed, flower, and die the same year in which they are developed. In such plants the roots are always of small size, and either all spring from a common point, as in annual Grasses (*fig.* 240); or the true root is small, and gives off from its sides a number of small branches. Such plants, in the process of flowering and maturing their fruits and seeds, exhaust all the nutriment they contain, and thus necessarily perish.

2. Biennial Roots.—These are produced by plants which spring from seed one year, but which do not flower and ripen their seeds till the second year, when they perish. Such roots are commonly enlarged in various ways at the close of the first season (*fig.* 250), in consequence of their tissue becoming gorged with nutritious matters stored up for the support of the plant during its flowering and fruiting the succeeding season. The Carrot (*fig.* 248) and Turnip (*fig.* 250) afford us good examples of biennial roots.

3. Perennial Roots.—These are the roots of plants which live for many years. In some such plants, as the Dahlia (*fig.* 244), Orchis (*fig.* 242), &c., the roots are the only portions of the plant which are thus perennial, their stems, &c., dying down to the ground yearly. Such perennial roots are either of woody consistence, or more or less fleshy as in biennial roots.

We have seen in treating of the stem that that organ possesses certain differences in its internal structure in the three great classes of Dicotyledonous, Monocotyledonous, and Acotyledonous Plants. The roots of such plants in like manner possess similar distinctive characters, and also some others, which render it necessary for us briefly to refer to them.

1. The Root of Dicotyledonous Plants.—The roots of these plants are formed, as we have seen, by the direct elongation of the radicle of the embryo (p. 119). Such a mode of root-development has been called by Richard and other botanists *exorhizal.*

It follows from this mode of development that Dicotyledonous Plants have generally a tap-root or descending central axis (*fig.* 233) from which branches are given off in various directions, in the same manner as such plants have also an ascending axis or

stem from which the branches arise. These tap-roots do not, however, commonly descend far into the ground, but their branches become much developed laterally ; in some cases even more so than those of the stem, while in others they are less so, as is especially the case in plants of the Gourd tribe, and commonly in all succulent plants.

In their internal structure the root resembles the stem except that it has no pith or medullary sheath, so that the woody part forms the central axis of the root. This absence of pith and medullary sheath is generally the case in herbaceous plants, but there are some trees, as, for instance, the Walnut and Horse-chestnut, where the pith is prolonged downwards for some distance into the root.

2. THE ROOT OF MONOCOTYLEDONOUS PLANTS. — In these plants the radicle does not itself become prolonged to form the root, but it generally gives off above its base one or more branches of equal size, which separately pierce the radicular extremity of the embryo, and become the roots (*fig.* 742, *r*); each of these is covered at its base, where it pierces the integuments, with a cellular sheath which is termed the *coleorhiza* (*fig.* 742, *co*). Such a mode of root-development has been termed by Richard *endorhizal.* The roots of Monocotyledonous Plants are therefore to be regarded as *adventitious* or *secondary.*

From their mode of development it rarely happens that the plants of this class have tap-roots, but they generally consist of a number of separate parts of nearly equal size (*fig.* 742), and hence are said to be *compound.* There are, however, exceptions to this, as for instance in the Dragon-tree (*fig.* 186), which has a central axis resembling the ordinary tap-root of Dicotyledonous Plants.

Aerial roots are much more common in Monocotyledonous then in Dicotyledonous Plants. We have already referred to them in the Screw-pine (*fig.* 178, 2). In many Palms they are developed in great abundance towards the base of the stem, by which that portion assumes a conical appearance, which is at once evident by the contrast it presents to the otherwise cylindrical stipe of such trees. In their internal structure the roots of Monocotyledonous Plants resemble those of the stem.

3. THE ROOT OF ACOTYLEDONOUS PLANTS.—Such plants, as we have seen, have no true seeds containing an embryo, but are propagated by spores which develope roots indifferently from any part of their surface, and hence have been called by Richard, *heterorhizal.* Such roots are therefore all adventitious. When the stem has become developed it soon gives origin to other adventitious roots, by which such plants are chiefly supported. Hence aerial roots are very common in Acotyledonous Plants, in which respect they resemble those of Monocotyledons. In Tree-Ferns also, as in many Palms, these roots are so abun-

dant at the base of their caudex, that they sometimes double or triple its thickness (*fig.* 159, *ra*), and hence give to the lower part of such stems a conical form. Their internal structure in all essential characters resembles that of the stem.

We have now, in conclusion with roots, to describe some of the more important forms which they present.

Forms of Roots.—When a root divides at once into a number of slender branches or rootlets, or if the primary root is but little enlarged, and gives off from its sides a multitude of similar branches, it is called *fibrous*. Such roots occur commonly in annual plants, and may be well seen in annual Grasses (*fig.* 240), in bulbous plants ((*figs.* 224 and 225),&c.

Fig. 240.

Fig. 241.

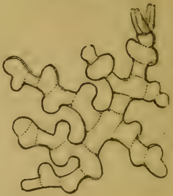


Fig. 240. Fibrous root of a Grass. *Fig.* 241. Coralline root from *Corallorrhiza innata*.

Coralline Root. — This name is applied to a root which consists of a number of succulent branches of nearly equal size,

Fig. 242.

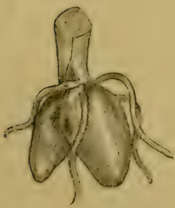


Fig. 243.

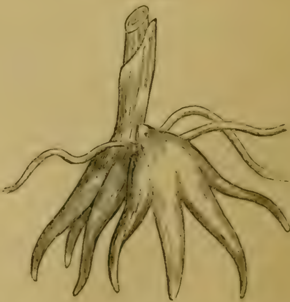


Fig. 242. Tubercular roots of an Orchis. —— *Fig.* 243. Palmated tubercules of an Orchis.

and arranged like a piece of coral (*fig.* 241), as in *Corallorrhiza innata.*

Tuberculated Root.—When some of the divisions of a root become enlarged so as to form more or less rounded or egg-shaped expansions (*fig.* 242), the root is said to be *tuberculated*, and each enlargement is called a *tubercle.* Such a root occurs in various terrestrial Orchids, the Jalap plant, &c. These tubercles must not be confounded with tubers, which have been already described as subterranean modifications of the stem. The presence of eyes or buds on the latter, at once distinguishes them. In many Orchids, as for instance the *Orchis maculata*, the tubercles are divided at their ends, so that the whole resembles the human hand (*fig.* 243), they are then said to be *palmated*, and the root is also thus termed.

Fig. 244.

Fig. 245.

Fig. 244. Fasciculated roots of the Dahlia. —— *Fig.* 245. Nodulose root of the common Dropwort (*Spirœa Filipendula*).

Fasciculated, Clustered, or Tufted Root.—These names are applied indifferently to a root which consists of a number of tubercles or fleshy branches arising from a common point (*fig.* 244), as in *Asphodelus luteus;* the Dahlia; Bird's-nest Orchis (*Neottia Nidus-avis*), &c.

Nodulose, Annulated, and Moniliform or Necklace-shaped Roots.—These terms are applied to roots which are expanded only at

certain points. Thus, when the branches are enlarged irregularly towards the ends, as in the common Dropwort (*Spiræa Filipendula*), the root is *nodulose* (*fig.* 245). When the branches have alternate contractions and expansions (*fig.* 246), so as to present a beaded appearance, as in *Pelargonium triste*, the root is termed *moniliform*, *necklace-shaped*, or *beaded*. When the root has a number of ring-like expansions on its surface, as in Ipecacuanha (*Cephaëlis Ipecacuanha*), it is *annulated* (*fig.* 247).

The above forms of roots, with few exceptions, are those which are commonly observed in plants which have no true tap-root. Those which have now to be described owe their peculiar forms to modifications of that kind of root.

Fig. 246.

Fig. 246. Moniliform root.

Fig. 247.

Fig. 248.

Fig. 247. Annulated root of Ipecacuanha (*Cephaëlis Ipecacuanha*).
Fig. 248. Conical root of the common Carrot.

Conical Root.—When a tap-root is broad at its base, and tapers towards the apex, it is termed *conical* (*fig.* 248). The roots of Monkshood (*Aconitum Napellus*); Horse-radish (*Cochlearia Armoracia*); the Parsnip (*Pastinaca sativa*); the Carrot (*Daucus Carota*); the Dandelion (*Leontodon Taraxacum*); are all familiar examples of this root.

Fusiform or Spindle-shaped Root.—This term is applied to a tap-root which swells out a little below its base, and then tapers

upwards and downwards (*fig.* 249). The common Radish (*Raphanus sativus*); and the Beet (*Beta vulgaris*) may be taken as examples of this form of root.

Napiform or Turnip-shaped Root.—This name is given to a root which is much swollen at its base, and tapers below into a long point, the whole being of a somewhat globular form (*fig.* 250). It occurs in a variety of the common Radish, which is

Fig. 249.

Fig. 250.

Fig. 251.

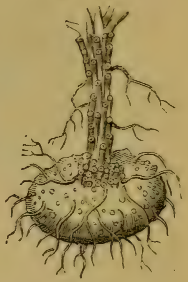


Fig. 251. Placentiform root.

Fig 249. Fusiform root of the common Radish.——*Fig.* 250. Napiform root of the Turnip.

hence called the Turnip-radish; in the common Turnip (*Brassica Napus*) and other plants. When what would be otherwise a napiform root becomes compressed both at its base and apex so that it has no tapering extremity, it is said to be *placentiform* (*fig.* 251). It occurs in the Sow-bread (*Cyclamen europæum*).

The recent researches of botanists have shown, that the so-called roots of the Radish, the Turnip, the Cyclamen, and probably some others, are really enlarged stems. We have, however, placed them here with the roots, in accordance with the commonly accepted views of their nature.

Contorted or twisted Root.—When the tap-root instead of proceeding in a more or less straight direction, becomes twisted (*fig* 252), as in the Bistort (*Polygonum Bistorta*), the above term is applied to it.

Fig. 252.

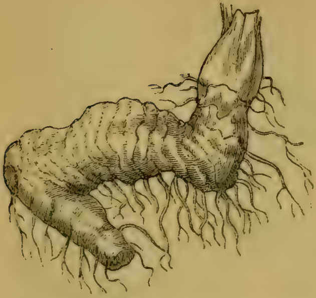


Fig. 253.

Fig. 252. Contorted root of Bistort (*Polygonum Bistorta*). —— *Fig.* 253. Præmorse root of the Devil's-bit Scabious (*Scabiosa succisa*).

Præmorse Root.—When the main root ends abruptly, so as to give the appearance of having been bitten off (*fig.* 253), it is called an *abrupt, truncated*, or *præmorse* root. We have a good example of this form of root in the Devil's-bit Scabious (*Scabiosa succisa*), which received its common name from a superstitious opinion connected with this peculiar bitten-off appearance of the root.

Section 3. The Leaf.

1. General description, and parts of the leaf.

The leaf may be defined as a lateral expansion of the parenchyma of the circumference of the stem, or its divisions. In the lowest plants which possess leaves, as in Mosses, this is its ordinary structure; but in all the higher classes, the leaf contains in addition to the parenchyma, a framework or skeleton for its support, consisting of wood-cells and vessels, which are in direct connexion with similar parts of the fibro-vascular system of the stem. We distinguish therefore, in such leaves, as in the stem, both a cellular and a fibro-vascular system,—the former constituting the soft parts, or the *parenchyma* of the leaf; the latter, the hard parts, which act as a mechanical sup-

port, and which, by their ramification, form what are called *veins*, *ribs*, or *nerves*.

The parts of the stem from which the leaves arise, are called, as we have already seen, *nodes;* and the space between two nodes, an *internode*. The part of the leaf next the stem is called the *base*, and the opposite extremity the *apex*. The surfaces of the leaf are sometimes called the *paginæ*; hence, in ordinary leaves, which have but two surfaces, we speak of the upper paginæ, and the lower. The terms upper and lower are applied to the two surfaces of the leaf, because in by far the greater number of plants, the leaves are placed horizontally, so that one surface looks to the heavens, and the other to the earth. We shall find however hereafter, that there are some leaves which are placed vertically, as in some Acacias, Eucalypti, &c. The lines connecting the base and apex of the leaf are called the *edges* or *margins*, or collectively the *circumscription*. The angle formed by the union of the upper surface of the leaf with the stem is called the *axil;* and everything which arises out of that point is said to be *axillary*. This is the normal position, as we have seen, of buds. If any body springs from the stem above, or below the axil, it is *extra-axillary;* or, as generally described when above, *supra-axillary;* if below, *infra-axillary*.

The Leaf varies as regards its duration, and receives different names accordingly. Thus, when it falls soon after its appearance, it is said to be *fugacious* or *caducous;* if it lasts throughout the season in which it is developed, *deciduous* or *annual;* or if beyond a single season, or until new leaves are developed, so that the stem is never without leaves, it is said to be *persistent*, *evergreen*, or *perennial*.

When a leaf separates from the stem, it either does so by decaying upon it, when it is said to be *non-articulated*, or by an articulation, in which case it is *articulated*. The remains of a non-articulated leaf, as they decay upon the stem, are sometimes called *reliquiæ* or *induviæ;* and the stem is said to be *induviate*. When a leaf separates by an articulation, it leaves a *scar*, *cicatricula*, or *cicatrix*.

The leaf in the highest state of development, consists of three distinct parts: namely, of an expanded portion, which is usually more or less flattened (*fig.* 254, *l*), called the *lamina*, *blade*, or *limb;* of a narrower portion, by which this is connected with the stem, called the *petiole* or *leaf-stalk* (*p*); and of a portion at the base of the petiole, or of the lamina, if that is absent, which either exists in the form of a *sheath* or *vagina* (*d*), encircling the stem, or as two little leaf-like appendages on each side, which are called *stipules* (*fig.* 255, *ss*).

These three portions are by no means always present, though this is frequently the case. Thus, the leaves of the Water

Pepper (*Polygonum Hydropiper*) (*fig.* 254), and of the Trailing

Fig. 254.

Fig. 255.

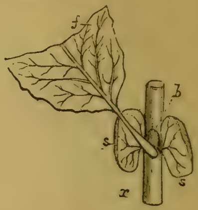


Fig. 255. Leaf and portion of a branch of *Salix aurita*. *r*. Branch. *b*. Bud. *f*. Lamina with the upper portion removed, and attached by a petiole below to the stem. *s s*. Caulinary stipules.

Fig. 254. Leaf and piece of the stem of *Polygonum Hydropiper*. *l*. Lamina or blade. *p*. Petiole. *d*. Sheath or vagina.

Sallow (*Salix aurita*) (*fig.* 255), may be taken as illustrations of such leaves:—the former representing the third portion in the form of a sheath (*d*), and the latter as stipules (*s s*). In many plants, one of these parts is absent, and in some two, so that the leaf is then reduced to but one of its portions only. The petiole, and the sheath or stipules of the leaf, are those parts which are more generally absent. When the petiole is absent, the leaf is said to be *sessile;* when the stipules are absent, it is *exstipulate.* The lamina or blade is that part which is most commonly present. The leaf is called *simple* if there is but one blade (*fig.* 254), or compound if this is divided into two or more separate parts (*fig.* 256). The lamina of the leaf is usually that part also which is most developed, which performs the more important functions of the leaf, and which is also in ordinary language known under the name of leaf. It is the part therefore, which will come more particularly under our notice. Before proceeding however to describe it and the other parts of the leaf separately, it will be far better, and more convenient for us to treat of the different modes in which leaves are inserted and arranged on the stem.

Fig. 256.

Fig. 256.—Compound leaf of Robinia, with spiny stipules at its base.

2. INSERTION, AND ARRANGEMENT OF LEAVES.

1. Insertion.—The point by which a leaf is attached to the stem is called its *insertion*. Leaves are inserted on various parts of the stem and branches, and receive different names accordingly. Thus the first leaves which are developed are called *cotyledons*, *nursing*, or *seminal;* the latter term however is a bad one, because it would indicate that these are the only leaves that exist in the seed, but this is not the case, as the gemmule or plumule also possesses rudimentary ones; the cotyledons are usually very different in their appearance from the ordinary leaves which succeed them. The first leaves which appear after the cotyledons are termed *primordial*. These, and the cotyledons, generally perish as soon as, or shortly after the development of the other ordinary leaves. The latter are called *radical*, when they arise at, or below the surface of the ground, and thus apparently from the root, but really from a shortened stem, or *crown of the root* as it is commonly called. Leaves are thus situated in what are termed acaulescent plants, as in many Violets, the Dandelion, Primrose, Plantain, &c. The leaves which arise from the main stem are called *cauline;* those from the branches *ramal;* and those from the base of, or upon the flower-stalks, *floral leaves* or *bracts*.

Fig. 257.

Fig. 257. Peltate leaf of the Indian Cress (*Tropæolum*).

When a leaf arises from the stem by means of a stalk it is said to be *stalked* or *petiolate* (*fig*. 255); when the blade of a leaf is fixed to the stalk by a point more or less within its margin, as in the Indian Cress (*fig*. 257), and Castor Oil, it is *peltate* or shield-shaped; when the stalk is absent, so that the blade arises directly from the stem, it is said to be *sessile* (*fig*. 263); when a leaf is enlarged at its base and clasps the stem from which it springs, it is *amplexicaul* or *embracing*, as in Fool's Parsley, &c. (*fig*. 258), or if it forms a complete sheath around it, as in Grasses generally (*figs*. 259 and 351, *g*) it is said to be *sheathing;* when a leaf is prolonged as it were from its base, so as to form a winged or leafy appendage down the stem, as in Thistles, it is *decurrent* (*fig*. 260); when the two sides of the base of a leaf project beyond the stem and unite (*fig*. 261), as in the Hare's-ear (*Bupleu-*

Fig. 258.

Fig. 258. Amplexicaul petiole of *Angelica*.

rum perfoliatum) and Yellow-wort (*Chlora perfoliata*), it is *perfoliate*, because the stem appears to pass through the leaf; or

Fig. 259.

Fig. 260.

Fig. 261.

Fig. 262.

Fig. 259. Sheathing leaf of a Grass.——*Fig.* 260. Decurrent leaf of a species of Thistle.——*Fig.* 261. Perfoliate leaf of a species of Hare's-ear (*Bupleurum rotundifolium.*)——*Fig.* 262. Connate leaves of a species of Honeysuckle (*Lonicera Caprifolium*).

when two leaves placed on opposite sides of the stem unite by their bases they are said to be *connate* (*fig.* 262), as in the Teasels (*Dipsacus fullonum* and *sylvestris*), and some species of Honeysuckle (*Lonicera Caprifolium*), &c.

2. The Arrangement of Leaves on the Stem or Phyllotaxy.—When only one leaf arises from a node, the leaves as they succeed each other are placed alternately on different sides of the stem, in which case they are said to be *alternate* (*fig.* 266). This arrangement occurs in nearly all Monocotyledonous Plants, and in the larger number of Dicotyledonous Plants also after the first two or three nodes are developed. When two leaves are produced at a node, they are usually placed on opposite sides of the stem, in which case they are said to be *opposite* (*fig.* 264); or when three or more leaves arise from the stem so as to be arranged around it in the form of a circle, they are said to be *verticillate* or *whorled* (*fig.* 263), and each circle is termed a

verticil or *whorl*. When leaves are opposite, the pairs as they succeed each other frequently cross at right angles, in which case they are said to *decussate* (*fig.* 264), and the arrangement is called *decussation*. When different whorls succeed each other it also frequently happens that a somewhat similar arrangement occurs, thus the leaves of one whorl correspond to the intervals

Fig. 263.

Fig. 264.

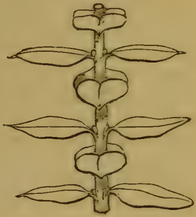


Fig. 263. Whorled leaves of a species of Galium.——*Fig.* 264. Decussate leaves of the *Pimelea decussata*.

of that below it. There are however commonly great irregularities in this respect, and in some cases the number of leaves in the different whorls vary, by which their arrangement becomes still more complicated. This is the case for instance in *Lysimachia vulgaris*.

Only one leaf can arise from the same point, but it sometimes happens that by the development of an axillary branch the internodes of which are scarcely developed, that all the leaves of that branch may be brought in contact at their base, in which case they form a *tuft* or *fascicle* (*fig.* 265), and the leaves are said to be *tufted* or *fascicled*. Such an arrangement is well seen in the Barberry and the Larch. That fascicled leaves are thus produced is rendered evident by the fact, that in the young branches of the Larch the internodes become elongated and the leaves consequently separated from each other.

Fig. 265.

Fig. 265. Fascicled leaves of the Larch.

The laws which regulate the arrangement of leaves upon the stem have of late years been carefully investigated; and when we consider that all the organs of the plant which succeed the leaves are modifications of them, and follow similar

laws, the determination of those laws must be considered to be a matter of much importance. It has been supposed by some that the arrangement of the leaves varies in the different classes of plants : thus, that in Dicotyledons where the cotyledons or first leaves which are developed are opposite, that the regular arrangement of the leaves in such plants is to be *opposite* or *whorled* also, and that when they become alternate, this arises from the prolongation or extension of the nodes: while in Monocotyledons on the contrary, which have but one cotyledon usually, or if more than one, then placed alternately, that the regular position of the leaves is *alternate* also, and that when they become opposite or whorled, that this arises from the non-development or shortening of the successive internodes. The investigations however of Bonnet nearly a century ago tended to prove that all leaves and their modifications have normally a spiral arrangement on the stem; and he was led to this belief by observing that if a line be drawn from the bottom to the top of a stem, so as to touch in succession the base of the different leaves upon its surface, it would describe a spiral around it; he found also, that the relation of the leaves to each other was constant, each being separated from the other by an equal distance, so that if we started with any particular leaf and waited until another leaf was reached which corresponded vertically with it, and then proceeded to the leaf beyond this, we should find that that would also correspond vertically with the one next above that which we started from, and so on each leaf as it succeeded the other above would be placed vertically over one of the successive leaves below, but that in all cases in the same plant the number of leaves between the one started from, and that which corresponded vertically with it was always the same. Thus if we take a branch of the Apple or Cherry-tree (*fig.* 266), and commence with any particular leaf which we will mark 1, and then proceed upwards connecting in our course the base of succeeding leaves by a line, or piece of string, we shall find that we shall pass the leaves marked 2 3 4 and 5, but that when we reach the one marked 6, that this will correspond vertically with the 1st, and then proceeding further, that the 7th will be directly over the 2nd, the 8th over the 3rd, the 9th over the 4th, the 10th over the 5th, and the

Fig. 266.

Fig. 266. A portion of a branch of a Cherry-tree, with six leaves, the sixth of which is placed vertically over the first. The right-hand figure is the same branch magnified. The numbers indicate the points of insertion of the leaves.

11th over the 6th and 1st, so that in all cases when the sixth leaf was reached including the one started from, a straight line might be drawn from below upwards to it, and that consequently there were five leaves thus necessary to complete the arrangement. Bonnet also discovered other more complicated arrangements in which more leaves were necessary for the purpose. His ideas were but little attended to at the time; recently however by the researches of Schimper, Braun, Bravais, and others, his views have been not only confirmed but considerably extended, and it has been shown that the spiral arrangement is not only universal, but that the laws which regulate it may be reduced to mathematical precision, the formulæ representing the relative position in different plants varying, but being always constant for the same species. The examination of these laws any further than to show that the regular arrangement of leaves and their modifications is in the form of a spiral round the stem, having at present no practical bearing in Botany, however interesting they may be in a mathematical point of view, would be out of place here; we shall confine ourselves therefore to the general discussion of the subject, and as alternate leaves are those which will enable us to do so with most facility, we shall allude to them first.

Alternate Leaves.—If we refer again to the arrangement of the leaves in the Cherry or Apple, we shall find that before we arrive at the sixth leaf (*fig.* 266), which is over the first, the string or line used to connect the base of the leaves will have passed twice round the circumference. The point where a leaf is found which is placed in a straight line, or perpendicularly over the first, shows the completion of a series or *cycle*, and thus in the Cherry and Apple, the cycle consists of five leaves. As the five leaves are equidistant from each other, and as the line which connects them passes twice round the stem, the distance of one leaf from the other will be $\frac{2}{5}$ of its circumference. The fraction $\frac{2}{5}$, therefore, is the *angular divergence*, or size of the arc interposed between the insertion of two successive leaves, or their distance from each other expressed in parts of the circumference of the circle, or $360° \div \frac{2}{5} = 144°$; the numerator indicates the number of turns made in completing the cycle, and the denominator the number of leaves contained in it. The successive leaves as they are produced on the stem, as we have seen, are also arranged in similar cycles. This arrangement of cycles of five is by far the most common in Dicotyledonous Plants. It is termed the *quincuncial*, *pentastichous*, or *five-ranked arrangement*.

A second variety of arrangement of alternate leaves is that which is called *distichous* or *two-ranked*. Here the second leaf is above and directly opposite to the first (*fig.* 267), and the third being in like manner opposite to the second, it is placed

Fig. 267.

Fig. 267. Portion of a branch of a Lime-tree, with four leaves arranged in a distichous or two-ranked manner.

vertically over the first, and thus completes the cycle, which here consists of but two leaves; the fourth leaf again is over the second, and the fifth over the third and first, thus completing a second cycle; and so on with the successive leaves. Here one turn completes the spiral, so that the angular divergence or distance between two successive leaves is $\frac{1}{2}$ the circumference of a circle, $360° \div \frac{1}{2} = 180°$. This arrangement is the normal one in all Grasses, and many other Monocotyledonous Plants; and the Lime-tree, and other Dicotyledonous Plants, exhibit a similar arrangement of their leaves.

A third variety of arrangement in alternate leaves is the *tristichous* or *three-ranked* (*fig.* 268). Thus, if we start with any leaf, and mark it No. 1, and then pass to 2 3 and 4, we shall find that we shall make one turn round the stem, and that the fourth leaf is vertically over the first, and thus completes a cycle composed of three leaves. In like manner, the fifth leaf will be over the second, the sixth over the third, and the seventh over the fourth and first, thus completing a second cycle; and so on with the succeeding leaves. Here the angular divergence is $\frac{1}{3}$, or one turn and three leaves, that is $360° \div \frac{1}{3} = 120°$. This arrangement is by far the more common one among Monocotyledonous Plants, and may be considered as the most characteristic of that class of plants, just as the pentastichous arrangement is of Dicotyledons.

Fig. 268.

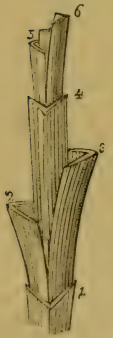


Fig. 268. Portion of a branch with the bases of the leaves of a kind of Carex, showing the tristichous, or three-ranked arrangement.

A fourth variety of Phyllotaxis in alternate leaves is the *octastichous* or *eight-ranked*. This occurs in the Holly, the Aconite, &c. In this, the ninth leaf is over the first, the tenth over the second, the eleventh over the third, and so on; thus taking eight leaves to complete the cycle; and, as the spiral line here makes three turns round the stem, the angular divergence will be $\frac{3}{8}$ of the circumference, $360° \div \frac{3}{8} = 135°$.

The above are the commoner forms of Phyllotaxy, but a

variety of others also occur, which become more complicated as the number of leaves &c., in the spire is increased; but in those cases, where the leaves, &c., are so numerous as to be close to each other, as in the Screw-pine, in the Pine-apple (*fig.* 706, 2), and in the fruit of Coniferous Plants (*fig.* 269), the spiral arrangement is at once evident. The table in the following page, slightly altered from M. Braun, and taken from Balfour's Class-Book of Botany, will exhibit the more common modes of angular divergence in leaves, and their modifications.

Fig. 269.

Fig. 269. Cone or fruit of the Scotch Fir (*Pinus silvestris*).

We have thus endeavoured to show that when leaves are alternate, these taken as a whole form a spiral round the axis. The spire may either turn from right to left, or from left to right. In the majority of cases, the direction in both the stem and branches is the same, and it is then said to be *homodromous;* but instances also occasionally occur in which the direction is different, when it is called *heterodromous.*

Besides the series of spirals which have been alluded to, others also occur, as $\frac{1}{4}$, $\frac{1}{5}$, $\frac{2}{9}$, $\frac{3}{14}$, $\frac{5}{23}$, &c.; also $\frac{1}{2}$, $\frac{2}{3}$, $\frac{3}{5}$, $\frac{5}{8}$, &c.; and others are also met with; these, however, are all of more or less rare occurrence, and it is unnecessary therefore for us to allude to them any further. It should be mentioned also with respect to the laws of Phyllotaxy, that they are frequently interfered with by accidental causes, which produce corresponding interruptions of growth, so that it is then difficult, or altogether impossible, to discover the regular condition.

All the above varieties of Phyllotaxis in which the angular divergence is such, that by it we may divide the circumference into an exact number of equal parts, so that the leaves completing the cycles must be necessarily directly over those commencing them, are called *rectiserial,* to distinguish them from those in which the divergence is such, that the circumference cannot be divided by it into an exact number of equal parts, and thus no leaf can be placed precisely in a straight line over any preceding leaf, but disposed in an infinite curve, and hence called *curviserial.* The first forms of arrangement are looked upon as the normal ones. The latter will show the impossibility of bringing organic forms and arrangements, in all cases, under exact mathematical laws.

Opposite and Verticillate Leaves.—We have already observed with regard to these forms of arrangement, that the successive pairs, or whorls, as they succeed each other, are not

DIVERGENCE.	DICOTYLEDONS.	MONOCOTYLEDONS.	ACOTYLEDONS.
$\frac{1}{2}$ Distichous.	Asarum. Lime. Vicia. Orobus. Pea.	Common in Gramineæ. Cyperus. Acorus Calamus.	Fissidens. Didymodon capillaceus.
$\frac{1}{3}$ Tristichous.	Cereus angularis (green fleshy divisions of the axis).	Carex. Colchicum autumnale.	Gymnostomum æstivum. Jungermannia tricophylla.
$\frac{2}{5}$ Pentastichous or Quincuncial.	Common in this class. Apple. Pear. Poplar. Cherry. Mezereon.	Eleocharis acicularis. Rhyncospora fusca.	Common.
$\frac{3}{8}$ Octastichous.	Laurus nobilis. Holly. Aconite. Plantago major.	Lilium candidum. Scirpus lacustris.	Common in Mosses. Lycopodium Selago.
$\frac{5}{13}$	Wormwood. Euphorbia segetalis. Convolvulus tricolor. Cones of White Pine and White Spruce.	Agave americana Many species of Orchis.	Orthotricum affine. Lastræa Filix-mas.
$\frac{8}{21}$	Isatis tinctoria. Plantago lanceolata. Cones of Pinus Picea.	Gymnadenia conopsea. Many species of Yucca.	Hypnum alopecurum. Polytrichum piliferum.
$\frac{13}{34}$	Euphorbia cæspitosa. Plantago media. Cones of some Pines. Sempervivum arboreum.	Yucca aloefolia. Ornithogalum pyrenaicum.	Sphagnum. Polytrichum formosum.
$\frac{21}{55}$	Cones of some Pines. Mammillaria coronaria (protuberances on the axis).		

By placing these fractions side by side in a line, thus :— $\frac{1}{2}, \frac{1}{3}, \frac{2}{5}, \frac{3}{8}, \frac{5}{13}, \frac{8}{21}, \frac{13}{34}, \frac{21}{55}$, we see at once that a certain relation exists between them ; for the numerator of each fraction is composed of the sum of the numerators, and the denominator of the sum of the denominators of the two preceding fractions : also that the numerator of each fraction is the denominator of the next but one preceding. By applying this simple law therefore we may continue the series of fractions representing the angular divergence, &c., thus :— $\frac{34}{89}, \frac{55}{144}, \frac{89}{233}$, &c.

commonly inserted immediately over the preceding, but that the second pair, or whorl, is placed over the intervals of the first, the third over those of the second, and so on. Here, therefore, the third pair of leaves will be directly over the first, the fourth over the second, the fifth over the third, &c. This arrangement occurs in plants of the Mint family, and is called decussation, as also previously noticed. In some cases, the succeeding pairs, or whorls, are not thus placed directly over the intervals of those below, but a little on one side, so that we shall have to pass to some higher pair or whorl than the third, before we arrive at one which is placed directly over the first. Such arrangements therefore clearly show that the successive pairs and whorls of leaves are arranged in a spiral manner with regard to each other. Opposite leaves may be thus looked upon as produced by two spirals proceeding up the stem simultaneously in two opposite directions, and the whorl is formed of as many spirals as there are component leaves.

The alternation and opposition of leaves is generally constant in the same species, and even in some cases throughout entire families of plants; thus, the Borage tribe (*Boragineæ*) have alternate leaves; the Peruvian Bark tribe (*Cinchonaceæ*), opposite; the Mint tribe (*Labiatæ*), opposite and decussate; the Madder tribe (*Rubiaceæ*), verticillate; the Pea tribe (*Leguminosæ*), alternate; the Rose tribe (*Rosaceæ*), alternate; &c. While the opposition or alternation of leaves may be thus shown to be constant throughout entire families, yet the change from one arrangement to another may be sometimes seen upon the same stem, as in the common Myrtle, in Snapdragon, &c. Other opposite-leaved plants also often exhibit an alternate arrangement at the extremities of their young branches when they grow very rapidly. In other cases, alternate leaves may become opposite, or whorled, by the non-development of the successive internodes by interruptions of growth; or, if the whole of the internodes of a branch become non-developed, the leaves become tufted or fascicled, as already noticed. As a general rule however, the relative position of leaves is sufficiently constant in the same species as to form one of its characteristic distinctions..

The arrangement of leaves probably influences, in some degree at least, the form of the stem and branches. Thus, a certain amount of alternation commonly leads to a rounded form of stem: an opposite, or whorled arrangement, to an angular stem; for instance, the Mint tribe of plants, which have opposite and decussate leaves, have square stems; the Nerium Oleander, where the leaves on the young branches are placed in whorls of three, the stem has three angles; and in the Madder tribe of plants, which have whorled leaves, the stems are always angular. M. Cagnat has also endeavoured to show that the

arrangement of the leaves has a direct influence upon the forms of the wood, bark, and pith; either upon one of those parts only, or sometimes upon them all; but, although some curious relations have been found to exist between the arrangement of the leaves and the form of certain parts of the stem, yet it is not possible at present to deduce any general laws regulating the relations between them.

Having now described the general arrangement of leaves when in an expanded state upon the stem or axis, we have in the next place to allude to the different modes in which they are disposed while in a rudimentary and unexpanded condition in the bud. To these the general name of Vernation or Præfoliation has been applied.

Vernation or Præfoliation.—Under this head we include:—1st, The modes in which each of the leaves considered independently of the others is disposed: and 2nd, The relation of the several leaves of the same bud taken as a whole, to each other. In the first place we shall consider the modes in which each of the leaves considered separately is disposed. We arrange these again in two divisions:—1st, Those in which the leaf is simply *bent* or *folded;* and 2nd, Those where it is *rolled.* Of the first modification we have three varieties:—Thus 1st, the upper half of the leaf may be bent upon the lower, so that its apex approaches the base, as in the Tulip-tree (*fig.* 270); it is then said

Fig. 270.

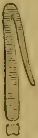


Fig. 271.

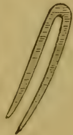


Fig. 272.

Fig. 273.

Fig. 274.

Fig. 275.

Fig. 276.

Fig. 270 Vertical section of a reclinate leaf.——*Fig.* 271. Transverse section of a conduplicate leaf.——*Fig.* 272. Transverse section of a plaited or plicate leaf.——*Fig.* 273. Vertical section of a circinate leaf.——*Fig.* 274. Transverse section of a convolute leaf.——*Fig.* 275. Transverse section of an involute leaf.——*Fig.* 276. Transverse section of a revolute leaf.

to be *reclinate* or *inflexed;* 2nd, the right half may be folded upon the left, the ends and midrib or axis of the leaf remaining immovable (*fig.* 271), as in the Oak and Magnolia, when it is called *conduplicate;* or 3rd, each leaf may be folded up a number of times like a fan, as in the Sycamore, Currant, and Vine (*fig.* 272), when it is *plaited* or *plicate.* Of the second modification we have four varieties:—1st, the apex may be rolled up on the axis of the leaf towards the base like a crosier, as in the Sundew and Ferns (*fig.* 273), when it is *circinate;* 2nd, the whole leaf may

be rolled up from one margin into a single coil, with the other margin exterior, as in the Apricot, Cherry, and Plantain, in which case it is *convolute* (*fig.* 274); 3rd, the two margins of the leaf may both be rolled inwards towards the midrib, which remains immoveable, as in the Violet, and Water-Lily (*fig.* 275), when it is *involute;* or 4th, the two margins may be rolled outwards or towards the lower surface of the leaf, as in the Rosemary, Lavender, and Azalea (*fig.* 276), in which case it is *revolute.*

We pass now to consider secondly, the relation of the several leaves of the same bud taken as a whole, to each other. Of this vernation we have several varieties which may be treated of in two divisions:—1st, Those in which the component leaves are plane or slightly convex ; and 2nd, Where they are bent or rolled. Of the first division we shall describe three varieties:—1st, that in which the leaves are placed nearly in a circle or at the same level, and in contact by their margins only, without overlapping one another (*fig.* 277), when they are *valvate;* 2nd, when they are at different levels, and the outer successively overlap the inner to a greater or less extent by their margins, as in the Lilac, and in the outer scales of the Sycamore (*fig.* 278), when they are said to be *imbricate;* or 3rd, if when leaves are placed, as in imbricate vernation, the margin of one leaf overlaps that of another, while it,

Fig. 277.

Fig. 278.

Fig. 279.

Fig. 280.

Fig. 281.

Fig. 282.

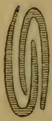


Fig. 283.

Fig. 277. Transverse section of a bud to show the leaves arranged in a valvate manner.
Fig. 278. Transverse section of a bud to show imbricate vernation.
Fig. 279. Transverse section of a bud to show twisted or spiral vernation.
Fig. 280. Transverse section of a bud to show induplicate vernation.
Fig. 281. Transverse section of a bud showing equitant vernation.
Fig. 282. Transverse section of a bud showing obvolute vernation.
Fig. 283. Transverse section of a bud showing supervolute vernation.

in its turn, is overlapped by a third (*fig.* 279), the vernation is *twisted* or *spiral.* We have now to describe the varieties of the second division, viz. where the component leaves of the bud are

bent or rolled. Of this we shall describe four varieties:—1st. When involute leaves are applied together in a circle without overlapping, they are said to be *induplicate* (*fig.* 280); 2nd, If the leaves are conduplicate, and the outer successively embrace and sit astride of those next within them as if on a saddle. As in Privet, and the leaves of the Iris at the base (*fig.* 281), they are *equitant;* or 3rd, If the half of one conduplicate leaf receives in its fold the half of another folded in the same manner, as in the Sage (*fig.* 282), the vernation is *half-equitant* or *obvolute;* and 4th, when a convolute leaf encloses another which is rolled up in a like manner, as in the Apricot, the vernation is *supervolute* (*fig.* 283).

The terms thus used in describing the different modes of vernation are also applied in like manner to the component parts of the flower-bud, under the collective name of *æstivation* or *præfloration.* We shall have therefore to refer to them again, together with some others, not found in the leaf-bud, when speaking of the flower-bud.

3. THE INTERNAL STRUCTURE OF LEAVES.

In describing the structure of leaves we shall divide them into two kinds, namely, *aerial* and *submerged*; by the former, we understand those that are produced and live in the air; by the latter, those that are formed and dwell wholly immersed in water.

1. Aërial Leaves.—In the lowest plants which possess leaves as already noticed (see p. 132), these consist simply of a cellular plate formed by an expansion or growing outwards of the parenchyma of the circumference of the stem; while in the majority of the higher plants they contain in addition to this parenchyma, a framework or skeleton formed of wood-cells, and vessels of different kinds, which are in direct connexion with the fibro-vascular system of the stem. We distinguish therefore, in such leaves, as in the stem — both a cellular and a fibro-vascular system — the former constituting the soft parts or the *parenchyma* of the leaf; the latter the hard parts, which by their ramification form what are called *veins*, *ribs*, or *nerves*.

The whole of the leaf is clothed by the epidermis, which is commonly furnished with stomata in the manner already described. The stomata are, however, almost confined to that portion of the epidermis which corresponds to the parenchyma of the leaf. The epidermis is also furnished with various appendages, as Hairs, Glands, &c. These, together with the epidermis, have been already fully described under their respective heads: we have now therefore only to allude to the parenchyma situated between the epidermis of the upper and lower surfaces of the leaf, and the fibro-vascular system constituting its veins.

a. *Fibro-vascular System.*—This is in direct connexion with that

of the stem in the three great classes of plants respectively. We shall now direct our attention more especially to that of the leaves of Dicotyledonous Plants.

The fibro-vascular system is in by far the majority of cases *double*, that is, consisting of an upper layer which is in connexion with the woody system of the stem (*fig.* 284, *t*, *v*, *f*); and a lower which is continuous with the liber (*l*). The upper layer therefore corresponds in its structure to the wood, and the lower to the liber; hence the former is composed of spiral and other vessels and wood-cells; while the latter consists essentially of liber-cells, and laticiferous vessels. To whatever extent the fibro-vascular system may branch, each division of the upper layer accurately corresponds at its apex with a similar division of the lower. This double layer of the fibro-vascular system is readily seen in what are called *skeleton leaves*, namely, those in which the parenchyma between the veins has been destroyed by maceration in water, or by other means; thus the leaves lying in a damp ditch in the winter will afford us good illustrations of these; similar leaves may be also artificially prepared by macerating for a sufficient time in water, &c.

Fig. 284.

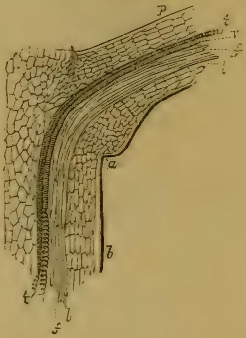


Fig. 284. Fibro-vascular bundle passing from a branch, *b*, of a Dicotyledonous Plant into the petiole, *p*. *a*. Articulation between the petiole and the branch from which it arises. *t*, *t*. Spiral vessels. *v*, *v*. Annular vessels. *f*, *f*. Wood-cells or fibres. *l*, *l*. Liber-cells.

Although the fibro-vascular system of a leaf is in general only double, instances do occur in which three layers of veins have been found. Thus Lindley has described an example of this kind in the leaves of *Theophrasta Jussiæi*. He says:—"In this plant there are three layers of veins, of which the middle is much reticulated, but the upper and lower are far less so, their fibres lying much more parallel with each other, and instead of being applied to the reticulations of the middle layer covering it obliquely."

The ramification of the fibro-vascular system in the lamina of the leaf forming the veins, ribs, or nerves, will be described presently under the head of *venation*.

b. *Parenchyma of Leaves.*—This has been also termed *diachyma* and *mesophyllum*. By it we understand the cellular tissue situated between the epidermis of the upper and lower surfaces of the leaf, and which surrounds the ramifications of the fibro-vascular system. It varies in amount in different leaves; in

ordinary leaves it is moderately developed, and they are then thin and flattened; while in others it is formed in large quantities, when they become thick and fleshy, and are termed *succulent.*

Fig. 285.

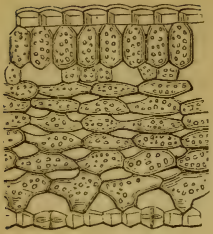


Fig. 285. Vertical section of a leaf of the White Lily highly magnified, showing the epidermis of both the upper and lower surfaces, with the intervening parenchyma.

The parenchyma also varies in its form and arrangement; in ordinary flat leaves we can readily distinguish two distinct layers of cells, one of which is placed beneath the epidermis of their upper surface, and the other beneath that of the lower. The whole of the cells are commonly green from the presence of chlorophyll in their interior. Beneath the epidermis of the upper surface we find one (*fig.* 285), two, or three layers of oblong blunt cells (*fig.* 286, *ps*), placed perpendicularly to the surface of the leaf. These cells are also placed closely against each other, and have no intervals but those formed by the unequal contact of such cells, except where stomata occur *st*, when spaces may be observed *m*, by

Fig. 286.

Fig. 286. Vertical section of a leaf of the Melon, highly magnified. *es.* Epidermal tissue of the upper surface, furnished with hairs, *p*, and stomata, *st.* *ei.* Epidermal tissue of the lower surface. *ps.* Three layers of upper parenchymatous cells. *pi.* Parenchymatous cells near to the epidermal tissue of the lower surface. *fv.* Fibro-vascular bundles. *m.* Cavities connected with the stomata. *l.* Cavities between the loose spongiform parenchyma.

which a communication is kept up between the external air and the interior of the leaf. The cells beneath the epidermis of the lower surface *ei*, are loosely connected *pi*, and have numerous large spaces between them; they are also frequently very irregular in form, thus presenting commonly two or more projecting rays, which become united with similar projections of the cells next them, and thus leave between them numerous spaces *l*, which communicate freely with each other, and form a cavernous or spongiform parenchyma. These spaces are also connected with the stomata, which, as we have already seen, are generally most abundant on the epidermis of the lower surface, and thus a free communication is kept up between the interior of the leaf and the external air, which is essential to the due performance of the functions of the leaf.

Such is the general arrangement of the parenchyma of leaves, but it is subject to various modifications in different plants. Thus in those leaves which present their margins to the earth and heavens instead of their surfaces, the arrangement of the parenchyma is similar beneath both of those surfaces. In succulent leaves again, the parenchyma is composed of cells usually larger than those of ordinary leaves, and closely compacted, or with but few interspaces; the cells in the centre of such leaves are also commonly colourless. Besides the above, various other modifications of the parenchyma occur in different plants, which it would be out of place to describe here, we therefore proceed to notice the structure of submerged leaves.

2. Submerged Leaves. — These are entirely made up of parenchyma, the veins being composed simply of cells more or less elongated. The cells of which the parenchyma is composed contain chlorophyll granules, and the leaves which are generally very thin, only contain two or three layers of them, so that they are all nearly in contact with the surrounding fluid; in such leaves the cells are disposed very regularly and have no interspaces. In submerged leaves however, which are thickened, we find large cavities which are very regular in their form and arrangement (*fig.* 287, *i*). These contain air, by which the specific gravity of the leaf is diminished, and it is thus enabled to float in the water. Submerged leaves have no true epidermal layer, and no stomata, both of which would be useless from their being

Fig. 287.

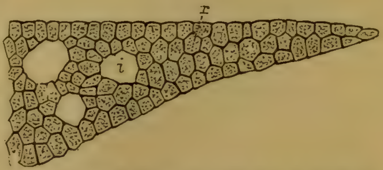


Fig. 287. Vertical section of a leaf of a Potamogeton highly magnified. *i.* Air cavities. *r.* Parenchymatous cells containing chlorophyll granules.

always exposed to similar hygrometric conditions. Such leaves when removed from the water and exposed to the air, speedily become dry and shrivelled; this is owing partly to the absence of an epidermis to control the evaporation of their fluids, and partly to the want of a fibro-vascular skeleton to act as a support to the surrounding parenchyma.

4. LAMINA OR BLADE.

We have already seen that the leaf (*figs.* 254 and 255) may consist of three parts; namely, of a *lamina* or *blade;* a *petiole* or *stalk;* and of a *vaginal* or *stipular* portion. We must now describe each of those portions, commencing with the *lamina* or *blade,* which is generally the most highly developed, and to which the name of leaf is commonly applied.

VENATION.—We will first describe the distribution of the veins of the lamina, to which the name of *Venation* has been given. The veins have also been called *Nerves*, and their distribution *Nervation;* but the latter are bad terms, indicating, as they do, an analogy between them and the nerves of animals, which is by no means the case; the former are those, therefore, which are more commonly and properly used.

In some plants, as Mosses, those living under water, &c., the leaves have no fibro-vascular skeleton, and consequently no true veins, and are hence said to be *veinless.* In succulent plants again, the veins are hidden more or less from view, in consequence of the great development of parenchyma. The leaves of such plants are therefore termed *hidden-veined.*

In those leaves where the veins are well marked, these are subject to various modifications of arrangement, the more important of which need only be mentioned here. When there is but one large central vein, which proceeds from the base to the apex of the lamina, and from which all the other veins proceed, this is called the *midrib* or *costa* (*fig.* 288). In other leaves there are three or more large veins, which thus proceed from the base to the apex, they are then termed *ribs* (*fig.* 289). The divisions or primary branches of these ribs are commonly called *veins*, and their smaller ramifications *veinlets.*

There are two principal modes in which the ribs and veins are distributed throughout the lamina. In the first place, the fibro-vascular bundle as it enters the leaf from the petiole or stem, may be continued as the midrib, or may divide into two or more ribs; from these other branches are given off, and from them, in like manner, other smaller ramifications arise, which unite with one another, so as to form a kind of network, as in *figs.* 288 and 289: or, secondly, the fibro-vascular bundle may be continued from the base to the apex of the leaf, and give off from its sides other veins, which run parallel to the margins, and

Fig. 288.

Fig. 289.

Fig. 288. Leaf of the Cherry with lamina, petiole, and stipules. A large central vein is seen to proceed from the petiole to the apex of the leaf, and to give off from its sides the other veins of the leaf. This central vein is termed the midrib.

Fig. 289. Ribbed leaf of the Melon with a dentate margin. The venation is said to be radiated or palmately veined.

which are simply connected by unbranched veinlets (*fig.* 290, *b*); or it may divide at once into several veins or ribs, which proceed from the base to the apex of the leaf, more or less parallel to each other, and are in like manner connected only by simple unbranched veinlets (*fig.* 290, *a*). The former are called *reticulated* or *netted-veined* leaves, and occur almost universally in Exogenous or Dicotyledonous Plants; the latter are termed *parallel-veined* leaves, and are characteristic of Endogenous or Monocotyledonous Plants.

Fig. 290.

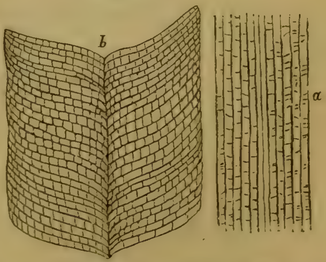


Fig. 290. *a*. Parallel venation of a Grass; this variety of venation is called straight-veined. *b*. A variety of parallel venation termed curve-veined as seen in the Plantain.

These two modifications are also subject to a variety of others, a few of which we shall now notice.

1. *Varieties of Reticulated Venation.*

a. *True netted.*—In such a leaf, the midrib gives off branches from its sides, which proceed at first towards the margins, and then curve towards the apex, terminating finally within the margin, with which they are connected by small veins, as in the Dead-nettle (*fig.* 291), Lilac, &c.

Fig. 291.

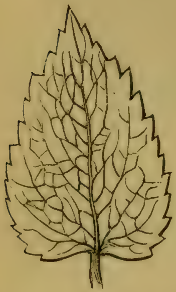


Fig. 291. Leaf of the Dead-nettle (*Lamium*). The venation is the true netted, and its margin is serrated.

Fig. 292.

Fig. 292. Feather-veined leaf of the Spanish Chestnut.

Fig. 293.

Fig. 293. Feather-veined leaf of the Oak. Its leaves are arranged in a pinnatifid manner.

b. *Feather-veined or pinnately-veined.*—In these the midrib gives off lateral veins which proceed at once to the margins, and are connected by numerous branching veinlets, as in the Beech, Chestnut (*fig.* 292), Holly, Oak (*fig.* 293), &c.

Fig. 294.

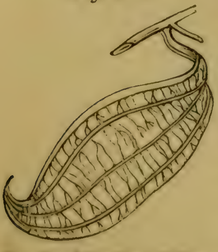


Fig. 294. Ribbed leaf of Cinnamon.

c. *Ribbed.*—This name is applied to a leaf which possesses three or more ribs that run in a curved manner from, at or near their base to the apex, towards which they converge; such ribs being connected together by branching veins, as in Cinnamon (*fig.* 294), Melastoma, &c. If a ribbed leaf has three ribs proceeding from the base, it is said to be *three-ribbed* or *tricostate*; if five, *five-ribbed* or *quinque-costate*; if more than five, *multicostate*. If the midrib of such a leaf gives off on each side, a little above its base, another rib, it is said to be *triple-*

ribbed or *tripli-costate*, as in the common Sunflower (*fig.* 295, *b*); or if two such ribs arise on each side of the midrib, it is termed *quintuple-ribbed* or *quintupli-costate*. These ribbed leaves have frequently a great resemblance to parallel-veined leaves, from which however, they may be at once distinguished by their ribs being connected by branching veins.

Fig. 295.

Fig. 295. *b*. Triple-nerved leaf of the common Sunflower. *a*. Linear leaf.

d. *Radiated or Palmately-veined.*—Such leaves resemble the former in consisting of three or more ribs which are connected by branching veins; but they are distinguished by the fact, that those, instead of converging to the apex, diverge from the base towards the circumference, as in the Sycamore, Currant, Vine, Geranium, Melon (*fig.* 289), &c.

2. *Varieties of Parallel Venation.*

The term parallel-veined is not strictly applicable in all cases, for it frequently happens that the veins are radiate, but from the difficulty of finding a name which will comprise all the modifications to which such leaves are liable, it must be understood that we apply the term parallel-veined to all leaves in which the main veins are more or less parallel and simply connected by unbranched veinlets. We distinguish two varieties of parallel venation.

a. *Straight-veined.*—In these leaves the veins either proceed in a parallel direction from the base to the apex, to which point they converge more or less (*fig.* 296), as in the ordinary ribbed variety of reticulated leaves already noticed, and are connected by simple unbranched veinlets; or they diverge from each other towards the circumference of the leaf (*fig.* 297), as in the radiated-veined variety of reticulated leaves. The leaves of Grasses, Lilies, and the common Flag may be taken as examples of the first modification; and those of the Palms of the second.

b. *Curve-veined.*—In such leaves we have a prominent midrib, which gives off from each of its sides along its whole length other veins, which proceed in a parallel direction towards, and lose themselves in, the margin (*figs.* 298 and 290, *b*). These veins are connected, as in those of the last variety by unbranched veinlets. The Banana, the Plantain, and allied plants, furnish us with examples of such leaves.

Besides the above two leading varieties of venation, the leaves of Ferns, and those of other Acotyledonous Plants which possess veins, present us with a third; thus, in these the pri-

Fig. 296.

Fig. 297.

Fig. 296. Leaf showing the variety of parallel venation called straight-veined. —— *Fig.* 297. Straight-veined variety of parallel venation, as seen in the leaf of the Fan Palm (*Chamærops*).

mary venation may be feather-veined or radiated, but the whole of their principal veins either divide in a forked manner (*fig.* 299), or their terminal ramifications are thus divided. Such a variety of venation may be therefore called *Furcate* or forked.

The leaves of the three great classes of plants present us, therefore, with three different modes of venation; thus, those of Dicotyledons are *reticulated*; those of Monocotyledons, *parallel*; and those of Acotyledons, *forked*.

Fig 298.

Fig. 299.

Fig. 298. Curve-veined variety of parallel venation, as seen in the Banana. —— *Fig.* 299. Forked venation of a Fern leaf. The margin is crenated.

Dr. McCosh has endeavoured to show that there is a general correspondence between the ramification of the tree and the venation of the leaf, in the fact that the angle formed by the branch with the stem, is the same as the angle of venation in the leaf. He states however that while it is comparatively easy to determine the angle of venation of the leaf, it is very difficult to ascertain the

normal ramification of the tree, for the angle at which the branch is given off is frequently modified by a great number of circumstances both natural and artificial. His researches have been almost confined to reticulated leaves, and he has given the following table of plants in which the angles of branching and venation were found to agree, — the angles being taken immediately below the points where the branches and veins were given off:—

	Deg.
Beech	45
Oak (large branches)	50
" (small branches and veins)	65—70
Cherry	50
Portugal Laurel	50—60
Bay Laurel	50—60
Holly	55—60
Rhododendron	60
Rose	50
Laburnum (small branches)	60
Box, about	60
Thistle	60—70
Thorn (lowest branches)	35—50
Ash	60
Bird Cherry	60
Red Dog-wood	45
Alder	50
Mountain Ash	45
&c. &c.	

Dr. McCosh also believes "that the analogy between the skeleton of the leaf, and the skeleton of the branch, may be seen in a number of other points; thus, some trees, such as the Birch, the Elm, the Oak, the Holly, the Portugal and Bay laurels, the Privet, the Box, will be found to send out side branches along the axis from the root, or near the very root; and the leaves of those trees have little or no petiole or leaf-stalk, but begin to expand from nearly the very place where the leaf springs from the stem. There are other trees, as the common Sycamore (the Scotch Plane-tree), the Beech, the Chestnut, the Pear, the Cherry, the Apple, which have a considerably long unbranched trunk; and the leaves of these trees will be found to have a pretty long leaf-stalk." The discussion of these views further would be incompatible with our object; and we refer those who desire further information upon these points to Dr. McCosh's papers read before the Botanical Society of Edinburgh, and his works on the subject.

Composition.—Leaves are divided into *simple* and *compound*. Thus a leaf is called simple if it has only one blade (*figs.* 288 —

298), however much this may be divided, so that the divisions do not extend to the midrib, or petiole; or in some cases the divisions even extend to the midrib, or petiole, but the leaf is still called simple when those are attached to these points by a broad base, as in fig. 307. A leaf is termed *compound*, when the midrib, or petiole divides so as to separate the blade into two or more portions, each of which bears the same relation to the petiole, as the petiole itself does to the stem from whence it arises (*fig.* 256). The separated portions of a compound leaf are called *leaflets* or *folioles;* and these may be either sessile (*figs.* 344—346), or have stalks (*figs.* 347 and 348), each of which is then termed a *petiolule* or *partial petiole*, and the main axis which supports them, the *rachis* or *common petiole.* The leaflets of a compound leaf may be at once distinguished from the separate leaves of a branch, from the fact of their being all situated in the same plane, and from the whole leaf commonly separating as one piece from the stem when it dies.

A simple leaf never has more than one articulation, which is placed at the point where it joins the stem; but a compound leaf frequently presents two or more, thus besides the common articulation to the stem, each of its separate leaflets may be also articulated to the common petiole upon which they are placed. This character frequently forms a good mark of distinction between simple and compound leaves, for although it is quite true that many compound leaves only present one articulation, and can then only be distinguished from those simple leaves which are divided to their midribs by the greater breadth of attachment of the divisions in the latter instances; yet, if such leaflets are articulated to the common petiole, their compound nature is at once evident. The presence of more than one articulation is therefore, positive proof as to the compound nature of a leaf, but the absence of such does not necessarily prove it to be simple, as is sometimes stated. We thus look upon the leaf of the common Orange which consists of only a single blade (*fig.* 300) as a compound leaf, because its petiole is not only articulated to the stem, but the blade is also articulated to the petiole. There are however numerous instances of leaves in a transitional state between simple and compound, so that it is impossible in all cases to draw a distinct line of demarcation between them. We shall now treat in detail of simple and compound leaves.

Fig. 300.

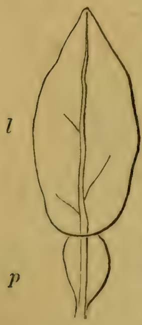


Fig. 300. Leaf of Orange (*Citrus Aurantium*). *p.* Winged petiole articulated to the lamina, *l.*

SIMPLE LEAVES.—The modifications which leaves present as

regards their form, general outline, &c., are almost infinite; hence we require a corresponding number of terms to define them. These terms are also applied in a similar sense to describe all the other compound organs of the plant which possess a definite shape, as the parts of the calyx, corolla, &c. It is absolutely necessary therefore that the student should understand their application before he can make any progress in descriptive botany. To treat of them fully here however would be out of place, as this part of the subject comes properly under the head of Glossology, or that department which has for its object "the terms used in botany." We shall confine our attention to the more important modifications.

According to DeCandolle, the shape of leaves depends upon the distribution and length of the veins, and the quantity of parenchyma which is developed between them; the general outline or figure being determined by the former, and the condition of the margin by the latter. These views have not however been confirmed by De Mercklin, who found, in studying the development of leaves, that the veins were not developed till a period subsequent to that of the parenchyma, and that, moreover, the form was generally established previous to their formation. The outline or figure of the leaf cannot therefore depend upon the veins. While the views of DeCandolle may be thus shown to be incorrect in a scientific point of view, still if that be borne in mind, it is convenient, to say the least, to study the almost infinite modifications of leaves with reference to his views, as it is always found that there is a mutual adaptation between the venation of the leaf and its general outline. We shall describe them accordingly to some extent after this manner, and in doing so we shall divide our subject into five heads to be treated of as follows:— 1. *Margin*; 2. *Incision*; 3. *Apex*; 4. *General Outline*; 5. *Form.*

1. *Margin.*—We have already stated that the condition of the margin is dependent upon the extent to which the par-

Fig. 300*a*.

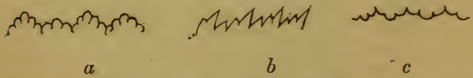


Fig. 300*a*. Diagram showing the condition of the margins of the leaves. *a.* Bicrenate. *b.* Biserrate. *c.* Duplicato-dentate.

enchyma is developed between the veins. Thus if the parenchyma completely fills up the interstices between them, so that the margin is perfectly even, or free from every kind of incision, the leaf is entire (*figs.* 296 and 300), as in the Orchis tribe. When the parenchyma does not reach the margin, but

terminates at a short distance within it, the leaf is said to be *indented* or *toothed*, of which we have several varieties. Thus if the teeth are sharp like a saw and all point to the apex, the leaf is *serrate* (*fig.* 291), as in the common Nettles. If these teeth are

Fig. 301.

Fig. 302.

Fig. 301. Sinuated leaf of the Oak.——*Fig.* 302. Spiny leaf of Holly (*Ilex Aquifolium*).

themselves serrate, it is *biserrate* or *duplicato-serrate* (*figs.* 300*a.* *b*, and 314), as in the Nettle-leaved Bell-flower. When the leaf is minutely serrate it is termed *serrulate*, as in *Barosma serrulata.* When the teeth are sharp, but do not point in any particular direction, and are separated by concavities, the leaf is *dentate* or *toothed* (*figs.* 289 and 354), as in *Nymphæa dentata*, and the lower leaves of the Corn Blue-bottle. When the teeth are themselves divided in a similar manner it is *duplicato-dentate* (*fig.* 300*a.* *c*). When the teeth are rounded (*figs.* 299 and 326) the leaf is *crenate*, as in Horse-radish, and Ground Ivy; or if these teeth are themselves crenated it is *bicrenate* (*fig.* 300*a*, *a*); or when the leaf is minutely crenated, it is said to be *crenulated.* When the margin presents alternately deep concavities and convexities it is *sinuate*, as in some Oaks (*fig.* 301); when the margin is slightly sinuous and wavy, as in the Holly (*fig.* 302), it is said to be *wavy* or *undulated;* or when the margin

Fig. 303.

Fig. 303. Crisped leaf of a species of Mallow (*Malva*).

is very irregular and twisted and curled, as in the Garden Endive, Curled Dock, and Curled Mint, it is said to be *crisped* or *curled* (*fig.* 303).

2. *Incision.*—This term is used when the margin is more deeply divided than in the above instances, so that the parenchyma does not usually extend more than about midway between it and the midrib, or petiole. The divisions are then commonly called *lobes*, and the leaf is described as two-lobed, three-lobed, four-lobed, &c., according to their number. It is usual however to give different names to these lobes, according to the depth of the incisions by which they are produced; thus if they reach to midway between the margin and midrib, or petiole, they are properly called *divisions* or *lobes* (*fig.* 293), and the intervals between them *fissures*, or in composition the term *-fid* is used, and the leaf is said to be *cleft;* if nearly to the base, or midrib (*fig.* 304), *partitions*, and the leaf is *partite;* if quite down to the base, or midrib, *segments* (*fig.* 305), and the leaf is *dissected*, or in composition *-sected.* These segments differ from the leaflets of compound leaves in not being articulated, and especially also in being united to the midrib, or petiole by a broad base.

In describing the above leaves we say that they are *bifid* or *two-cleft*, *trifid* or *three-cleft*, *quinquefid* or *five-cleft*, *septemfid* or *seven-cleft*, or *multifid* (*many-cleft*), according to the number of their fissures. A leaf is also said to be *tripartite*, or *trisected*, &c., in the same manner, according to the number of partitions or segments. These terms are especially used with palmately veined leaves.

The divisions of leaves are always arranged in the direction of the prominent veins. Thus those of feather-veined or pinnately veined leaves are directed towards the midrib; while those of palmately or radiated veined are arranged towards the base of the leaf. Hence instead of using terms indicating the number of lobes, &c., of a leaf, others are frequently employed that define the leaf more accurately, and which are derived from the mode of venation combined with that of division. Thus if the leaf is feather-veined and the incisions consequently arranged in that manner, it is said to be *pinnati-*

Fig. 304. *Fig.* 305.

Fig. 304. Leaf of the Valerian (*Valeriana dioica*). —— *Fig.*305. Leaf of a species of Poppy (*Papaver Argemone*).

Fig. 306.

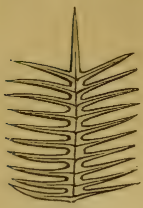


Fig. 306. Pectinate or comb-shaped leaf.

fid (*fig.* 293), as in the common Oak, or *pinnatipartite* (*fig.* 304), as in *Valeriana dioica*, or *pinnatisected* (*fig.* 305), according to their depth, as already described. If the divisions are themselves divided in a similar manner to the leaf itself, it is *bipinnatifid*, *bipinnatipartite*, or *bipinnatisected*, &c. Or, if the subdivisions of these are again divided in a similar manner, *tripinnatifid*, *tripinnatipartite*, *tripinnatisected*, &c. Or, if the leaf is still further divided, it is said to be *decomposed*, *laciniated*, or slashed.

Certain modifications of these forms again, have also received special names; thus when the lobes of a pinnatifid leaf are very close and narrow, like the teeth of a comb (*fig.* 306), it is *pectinate*, as in the Water Milfoil, all Mertensias, &c.; if the terminal lobe is large and rounded, and the lateral lobes which

Fig. 307.

Fig. 308.

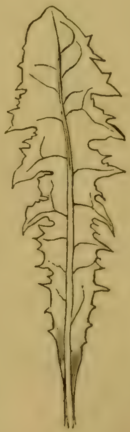


Fig. 309.

Fig. 307. Lyrate leaf of the common Turnip (*Brassica Rapa*).——*Fig.* 308. Runcinate leaf of Dandelion (*Leontodon Taraxacum*).——*Fig.* 309. Fiddle-shaped leaf of *Rumex pulcher*.

are also more or less rounded become gradually smaller towards the base (*fig.* 307), it is *lyrate*, or *lyre-shaped*, as in the common Turnip and Barbarea; when the terminal lobe is triangular, and the other lobes which are also more or less of the same shape

have their points directed downwards towards the base, as in Dandelion, it is said to be *runcinate* (*fig.* 308); when a lyrate leaf has but one deep recess on each side, so that it resembles a violin in shape (*fig.* 309), it is termed *panduriform* or fiddle-shaped, as in the Fiddle Dock.

The above terms are those which define lobed feather-veined leaves; when they are palmately veined and lobed in various ways, other terms are used according to the degree of division. In describing such leaves, the terms *bifid*, *trifid*, *quinquefid*, *septemfid*, *multifid*, are employed according to the number of their fissures, as already noticed; or the terms *palmatifid*. *palmatipartite*, *palmatisected*, derived from the direction of the veins, &c., may be used. Special names are also applied to certain modifications of these, as is the case with the feather-veined leaves. Thus, when a leaf has five spreading lobes united at their base by a more or less broad expansion of parenchyma, so that the whole has a resemblance to the palm of the hand with spreading fingers, it is termed *palmate* (*fig.* 310), as in some species of Passionflower, and in the Palmated Rhubarb; or when there are more than five lobes, the leaf is described as *palmatifid* or *palmately cleft*, as in

Fig. 310.

Fig. 311.

Fig. 310. Palmate leaf of a species of Passionflower (*Passiflora*).—— *Fig.* 311. Palmatifid leaf of the Castor-Oil plant (*Ricinus communis*).

the Castor-oil plant (*fig.* 311). Some writers however, use the terms palmate and palmatifid indifferently to describe either of the above forms of leaves, but the sense in which they are defined above, is far more precise, and should alone be used. When the lobes are less spreading, narrower, and somewhat deeper than in a true palmate leaf, it is *digitate*; when there are more than five lobes of a similar character, as in the Bitter Cassava, it is sometimes termed *digitipartite*, or even *digitate*, (though improperly so,) by some authors. When the leaf is divided nearly to its base into numerous narrow divisions, it is *dissected*.

as in *Geranium dissectum;* or if these divisions are very narrow and thread-like, as in the submerged leaves of the Water Crowfoot (*fig.* 312), it is said to be *filiformly dissected.* When

Fig. 312.

Fig. 312. Filiformly dissected leaf of the Water Crowfoot (*Ranunculus aquatilis*).

the lateral lobes of a palmate leaf are themselves divided into two or more divisions (*fig.* 313), the leaf is said to be *pedate*, from the resemblance it is supposed to bear to a bird's foot, as in Stinking Hellebore. This kind of leaf is by some botanists described as compound, to which division, in many cases at least, it properly belongs. It may be considered as a transitional form between simple and compound leaves. Besides the above modifications of palmately veined leaves, others also occur, in consequence of the lobes becoming themselves divided, either in a pinnately veined, or palmately veined manner, and terms are used accordingly, the application of which will be at once evident from what we have above stated.

Fig. 313.

Fig. 313. Pedate leaf.

3. *Apex.*—This differs very considerably in its appearance in different leaves. Thus the apex is *obtuse* or blunt, when it is rounded or forms the segment of a circle (*figs.* 321, 323, and 324), as in the Primrose and Snowdrop; it is termed *retuse* when it is obtuse, with a broad shallow notch in the middle (*fig.* 327), as in the Red Whortleberry (*Vaccinium Vitis-idæa*); when under the same circumstances the notch is sharp, or nearly triangular,

it is *emarginate*, as in some kinds of Senna (*Cassia obovata*) (*fig.* 313*a*), and common Box (*Buxus sempervirens*); when the leaf terminates very abruptly, as if it had been cut across in a

Fig. 313*a*.

Fig. 313*b*.

Fig. 313*a*. Leaflet of *Cassia obovata*. It is obovate in form, oblique at the base, and emarginate at its apex. —— *Fig.* 313*b*. Branch of Tulip-tree (*Liriodendron tulipifera*) with flower and leaves. The latter terminate abruptly, hence they are said to be *truncate*.

straight line, it is *truncate*, as in the leaf of the Tulip-tree (*Liriodendron tulipifera*) (*fig.* 313*b*); if under the same circumstances the termination is ragged and irregular, as if it had been bitten off, it is *præmorse*, as in the leaf of *Caryota urens*. When the apex is sharp, so that the two margins form an acute angle with each other (*fig.* 320 and 322), it is *acute* or *sharp-pointed*, as in the leaf of the Lady's Slipper (*Cypripedium Calceolus*) and most lanceolate leaves; when the point is very long, and tapering (*figs.* 317 and 320), it is *acuminate* or taper-pointed, as in the leaf of the White Willow (*Salix alba*) and common Reed (*Phragmites communis*); when it tapers gradually into a rigid point, it is *cuspidate*, as in many Rubi; when the apex is rounded, and has a short hard or softened point standing on it, it is *mucronate*, (*fig.* 319), as in the leaf of *Statice mucronata*, and *Lathyrus pratensis*.

4. *General Outline*.—By the general outline of the leaf we understand the superficial aspect or figure which is described by its margins. This is subject to great variations depending as we have seen, according to DeCandolle (p. 157), upon the direction and length of the veins. The development of veins and parenchyma is usually nearly equal on the two sides of the midrib, or petiole, so that the leaf in most instances is nearly symmetrical and of some regular figure; in which case it is said to be *equal* (*figs.* 320—323). When, as occasionally happens, the leaf is more developed on one side than on the other, it is termed *unequal* or oblique (*fig.* 313*a*); this is remarkably the case in the Begonias (*fig.* 315).

Generally speaking the leaves with true-netted or feather-veined venation are longer than broad, which is also commonly the case with parallel-veined leaves ; while those which are radiated or palmately veined are more or less rounded. When a leaf is nearly of the same breadth at the base as near the apex, narrow, and with the two margins parallel (*figs.* 295, *a*, and 316),

Fig. 314. *Fig.* 315. *Fig.* 316. *Fig.* 317.

Fig. 320. *Fig.* 321. *Fig.* 322. *Fig.* 323.

Fig. 314. Leaf of Elm, with its margin biserrate, and unequal at its base. —— *Fig.* 315. Unequal or oblique leaf of a species of Begonia. —— *Fig.* 316. Linear leaf of Goose-grass (*Galium Aparine*). —— *Fig.* 317. Lanceolate leaf. —— *Fig.* 318. Accrose or needle-shaped leaves of Juniper (*Juniperus communis*). —— *Fig.* 319. A cuneate and mucronate-pointed leaf. —— *Fig.* 320. Cordate and acuminate leaf. —— *Fig.* 321. Oblong leaf of Bladder-Senna (*Colutea arborescens*). —— *Fig.* 322. Ovate leaf, with its margin serrated. —— *Fig.* 323. Obovate leaf.

it is called *linear*, as in *Gentiana Pneumonanthe*, and most Grasses ; when a linear leaf terminates in a sharp rigid point like a needle, as in the common Juniper (*Juniperus communis*), and in many of our Pines, Firs, and Larches, it is *accrose* or *needle-shaped* (*fig.* 318). When a leaf is very narrow, and tapers

from the base to a very fine point, so that it resembles an awl in shape, as in the common Furze (*Ulex europæus*), it is *subulate* or *awl-shaped*. When a leaf is broader at the centre than at its two extremities, and tapers towards both base and apex, as in the White Willow (*Salix alba*), it is *lanceolate* (*fig.* 317); when it is longer than broad, of the same breadth at its base and apex, and slightly acute at those points, it is *oval* or *elliptical* (*fig.* 325), as in the Lily of the Valley (*Convallaria majalis*); and if under the same circumstances it is obtuse or rounded at each end (*fig.* 321), it is *oblong;* the latter term is better applied only to leaves which are longer than those of an elliptical form, and either acute or rounded at the two extremities, it was used in this sense by Sir J. E. Smith; the above definitions of elliptical and oblong are those of Lindley. If a leaf is broader at the base than at the apex, which is more or less rounded, so that the whole is of the shape of an egg cut lengthwise, it is *ovate* or *egg-shaped* (*fig.* 322), as in the Periwinkle (*Vinca major*); or if of the same figure, but with the apex broader than the base (*fig.* 323), it is *obovate* or *inversely egg-shaped.* When a leaf is broad at the apex, and abrupt-pointed, and tapers towards the base (*fig.* 319), as in some Saxifrages, it is *cuneate, cuneiform*, or *wedge-shaped;* if the apex is broad and rounded, and tapers down to the base (*fig.* 324), it is spathulate, as in the Daisy. When a leaf is broad and hollowed out at its base into two round lobes, and

Fig. 325.

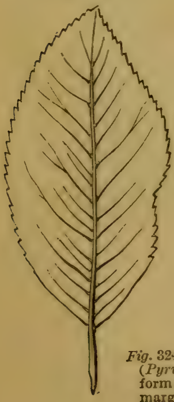


Fig. 324.

Fig. 326.

Fig. 327.

Fig. 324. Spathulate leaf.——*Fig.* 325. Oval leaf of Pear-tree (*Pyrus communis*), with a serrated margin.——*Fig.* 326. Reniform leaf of Ground Ivy (*Nepeta Glechoma*), with a crenate margin.——*Fig.* 327. Trifoliate leaf with obcordate leaflets.

more or less pointed at the apex, so that it somewhat resembles the heart in a pack of cards, it is *cordate* or heart-shaped (*fig.*

320), as in the Black Bryony (*Tamus communis*); or, if of the same shape, but with the apex broader than the base, and hollowed out into two round lobes, it is *obcordate* or inversely heart-shaped (*fig.* 327); when a leaf resembles a cordate one generally in shape, but with its apex rounded, and the whole

Fig. 328.

Fig. 329.

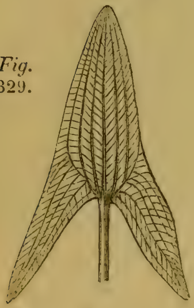


Fig. 331.

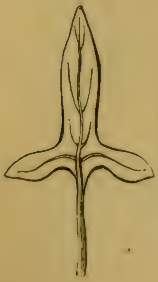


Fig. 330.

Fig. 332.

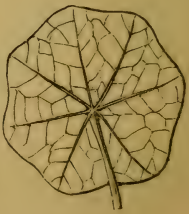


Fig. 333.

Fig. 328. Lunate or crescent-shaped leaf. —— *Fig.* 329. Sagittate leaf.—— *Fig.* 330. Hastate leaf. —— *Fig.* 331. A portion of the stem of Woody Nightshade (*Solanum Dulcamara*), bearing flowering stalk and an auriculate leaf. —— *Fig.* 332. A subrotund or rounded leaf, with entire margin. —— *Fig.* 333. Orbicular peltate leaf.

usually shorter, and broader (*fig.* 326), it is *reniform* or kidney-shaped, as in the Asarabacca (*Asarum europæum*); when a leaf is reniform but with the lobes at the base pointed, so that it resembles the form of a crescent (*fig.* 328), it is *lunate* or crescent-shaped, as in *Passiflora lunata*. When a leaf is broad and hollowed out at its base into two acute lobes, and pointed at the apex, so that it resembles the head of an arrow (*fig.* 329), it is *sagittate* or arrow-shaped, as in the Arrow-head (*Sagittaria sagittifolia*); when the lobes of such a leaf are placed horizontally, instead of passing downwards, it is *hastate* or halbert-shaped (*fig.* 330), as in Sheep's Sorrel (*Rumex Acetosella*); when the lobes of such a leaf are separated from the blade, as in the upper leaves of the Woody Night-shade (*Solanum Dulcamara*), it is *auriculate* (*fig.* 331). When a leaf is perfectly round, it is *orbicular* (*fig.* 333), a figure which is scarcely or ever found, but when it approaches to orbicular as in *Pyrola rotundifolia*, it is *subrotund* or *rounded* (*fig.* 332).

It frequently happens, that a leaf does not present accurately any of the above-described figures, but exhibits a combination of two of them, in which case we use such terms, as *ovate-lanceolate*, *linear-lanceolate*, *cordate-ovate*, *cordate-lanceolate*, *elliptico-lanceolate*, *roundish-ovate*, &c., the application of which will be at once evident.

5. *Form.*—By this term we understand the solid configuration of a leaf, that is including its length, breadth, and thickness. The terms used in defining the various forms are therefore especially applicable to thick, fleshy, or succulent leaves – namely, those which are commonly produced when the veins are developed in various planes, and connected by a large development of parenchyma. Such leaves either assume some regular geometrical figures, as *cylindrical*, *pyramidal*, *conical*, *prismatic*, &c., or approach to some well known objects, and are hence termed *ensiform* or *sword-like*, *acinaciform* or *scimitar-shaped*, *dolabriform* or *axe-shaped*, *clavate* or *club-shaped*, *linguiform* or *tongue-shaped*, &c. The above terms need no further description. In other instances, the leaf instead of having its veins entirely connected by parenchyma, is more or less hollowed out in its centre, when it is said to be *tubular*, *hood-shaped*, *urn-shaped*, &c.; various other singular forms are also found, some of which will be hereafter alluded to in speaking of the transformation of leaves.

Besides the above-described modifications of Outline, Form, Margins, &c., of simple leaves, they also present various others, when we regard their *surface*, *texture*, *colour*, &c. For their elucidation however we must refer to the general contents of this volume.

Compound Leaves.—We have already defined a compound leaf (see p. 156). Its separate parts or leaflets present all the modifications of margins, incision, apex, outline, form, &c., as

simple leaves, and similar terms are accordingly used in describing them. We have now therefore only to speak of compound leaves as a whole, and the terms which are used in describing their various modifications. We divide them into two heads, namely, 1. *Pinnately or feather veined Compound leaves*, and 2. *Palmately or radiated veined Compound leaves.*

1. *Pinnately-veined Compound leaves.*—When a leaf presenting this kind of venation is separated into distinct portions or leaflets, it is termed *pinnate* (*fig.* 334). The leaflets (or *pinnæ* as they are then called) are arranged along the sides of the rachis or common petiole in pairs, and according to their number, the leaf is said to be *unijugate* or *one-paired*, as in *Lathyrus sylvestris* and *latifolius*, *bijugate* or *two-paired*, *trijugate* or *three-paired*, and *multijugate* or many-paired (*fig.* 334). Several kinds of pinnate leaves have been distinguished. Thus

Fig. 335.

Fig. 334.

Fig. 336.

Fig. 337.

Fig. 334. Impari-pinnate or unequally pinnate leaf of *Robinia.* —— *Fig.* 335. Equally or abruptly pinnate leaf. —— *Fig.* 336. Interruptedly pinnate leaf of the Potato (*Solanum tuberosum*). —— *Fig.* 337. Lyrately pinnate leaf.

when a pinnate leaf ends in a single leaflet (*fig.* 334), as in Roses and the Elder, it is *impari-pinnate* or *unequally pinnate*, or pinnate with an odd leaflet ; it is *equally* or *abruptly pinnate*, or *pari-pinnate*, when it ends in a pair of leaflets or pinnæ (*fig.* 335),

as in some species *Cassia*, and *Orobus tuberosus*; it is *interruptedly pinnate* (*fig.* 336) when the leaflets are of different sizes, so that small pinnæ are regularly or irregularly intermixed with larger ones, as in the Potato and Silver Weed (*Potentilla anserina*). When the terminal leaflet of a pinnate leaf is largest, and the rest gradually smaller as they approach the base (*fig.* 337), it is *lyrately pinnate*; this leaf and the true lyrate are frequently confounded together by botanists, and the two forms frequently run into each other, so that it is by no means uncommon to find both on the same plant, as in the common Turnip and Yellow Rocket.

When the leaflets of a pinnate leaf become themselves pinnate, or in other words when the partial petioles which are arranged on the common petiole exhibit the characters of an ordinary pinnate leaf, it is said to be *bipinnate* (*fig.* 338 and 366),

Fig. 338.

Fig. 339.

Fig. 338. Bipinnate leaf of a species of Gleditschia. —— *Fig.* 399. A tripinnate leaf.

Fig. 340.

Fig. 340. A decompound leaf.

as in some species of Acacia. The leaflets borne by the partial or secondary petioles are commonly termed *pinnules.* When the pinnules of a bipinnate leaf become themselves pinnate, it is *tripinnate* (*fig.* 339), as in the Meadow Rue (*Thalictrum minus*). When the division extends beyond this, the leaf is *decompound* (*fig.* 340), as in many Umbelliferous Plants.

2. *Palmately-veined Compound leaves.*—Such a leaf is produced when the ribs of a palmately veined leaf bear separate leaflets. These leaves are readily distinguished from those of the pinnate kind, by their leaflets coming off from the same point. We distinguish several kinds: thus, a leaf is said to be *binate, bifoliate,* or *unijugate,* if it consists of only two leaflets springing from a common point (*fig.* 341), as in Zygophyllum ; it is *ternate* or *trifoliate* if it consists of three arranged in a similar manner (*figs.* 327 and 342), as in the genus *Trifolium* (Trefoil), which receives its name from this circumstance ; it is *quadrinate* or *quadrifoliate* if there are four leaflets (*fig.* 343), as in Herb

Fig. 341. *Fig.* 342. *Fig.* 343.

Fig. 341. A binate leaf.——*Fig.* 342. Ternate or trifoliate leaf. *Fig.* 343. Quadrifoliate leaf of *Marsilea quadrifolia.*

Paris (*Paris quadrifolia*) ; it is *quinate* or *quinquefoliate* if there are five (*fig.* 344), as in *Potentilla argentea* and *alba* ; it is *septenate* or *septemfoliate*, if there are seven (*fig.* 345), as in the Horse-chestnut and some Potentillas ; it is *multifoliate* if there

Fig. 344.

Fig. 345.

Fig. 344. Quinate or quinquefoliate leaf. —— *Fig.* 345. Septenate leaf of the Horse-chestnut (*Æsculus Hippocastanum*).

are more than seven (*fig.* 346), as in many of the Lupin tribe. The term *digitate* is sometimes employed to characterise a compound leaf of five leaflets, but this name should be confined to a simple leaf, and used in the sense already noticed. In speaking of palmately veined compound leaves in a general sense, they are usually termed *palmate* or *digitate*.

These leaves may become still more divided. Thus if the common petiole divides at its apex into three partial ones, each of which bears three leaflets (*fig.* 347), as in the Masterwort

Fig. 346.

Fig. 347.

Fig. 346. Multifoliate leaf of a Lupin. —— *Fig.* 347. A biternate leaf.

(*Imperatoria Ostruthium*), it is *biternate*; or when the common petiole divides at its apex into three secondary ones, and each of these again divides into three others, each of which bears three leaflets, as in the Yellow Fumitory (*Corydalis lutea*), and

Epimedium, it is *triternate* or *triply ternate* (*fig.* 348); when such a leaf is still further divided, it is said to be decompound.

Fig. 348.

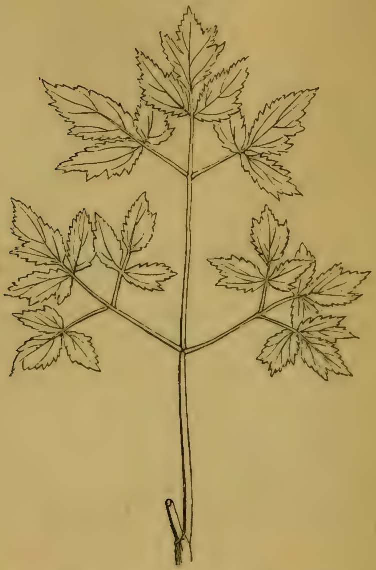


Fig. 348. Triternate leaf of Bane-berry (*Actæa*).

5. PETIOLE OR LEAF-STALK.

The petiole or leaf-stalk is that part which connects the blade of the leaf with the stem (*figs.* 284 and 349). It is frequently absent, and the leaf is then said to be sessile (*fig.* 263). It consists of one or more vascular bundles, surrounded by parenchyma (*fig.* 349, *fv*, *pc*), and the whole is enclosed in a layer of epidermis, which contains but few, or no stomata. The vascular bundles vary in their nature in the leaves of the different classes of plants, being merely prolongations of those of the three kinds of stem already fully described; thus, in Dicotyledonous Plants, the vascular bundles which proceed from the interior of the stem, as shown in *fig.* 284, consist of spiral, pitted, and laticiferous vessels, and wood-cells, or of the same elements essentially, as the wood itself. The ramification of the

vascular bundles of the petiole in the lamina or blade constitute the ribs or veins of the leaves, which have been already described under the head of venation.

The petiole is either *simple* or undivided, as in all simple leaves, and in those of a compound character in which the leaflets are sessile; or it is said to be *compound* when it divides into two or more portions, each of which bears a leaflet. The divisions of the petiole or the stalks of the leaflets are then called *petiolules*, *stalklets*, or *partial petioles*, while the main petiole is called the *rachis* or *common petiole*.

Fig. 349.

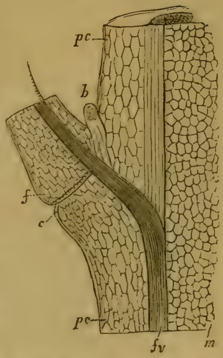


Fig. 349. Section of a stem and the base of a leaf, showing the passage of a fibro-vascular bundle *fv* into the petiole. *pc, pc*. Parenchymatous tissue of the stem and petiole. *c*. Pulvinus. *f*. Articulation between the leaf and stem. *b*. Leaf bud in the axil of the leaf.

The petiole is frequently more or less contracted at the base where it joins the stem owing to the presence of an *articulation* or *joint* (*fig.* 349, *f*). Leaves thus furnished with an articulated petiole fall away from the stem after they have performed their functions; in doing so they leave a scar, called a *cicatrix* (*fig.* 193), which frequently exhibits on its surface several little points, which are produced by the rupture of the vascular bundles of the petiole (*fig.* 193). The outline of the cicatrix and the arrangement of the vascular bundles vary much in different species, and thus frequently form characters by which we may distinguish plants after the leaves have fallen. Lestibaudais has also endeavoured to show, that the number and distribution of the vascular bundles of the petiole influence, to some extent at least, the arrangement of leaves upon the stem, and also their varying forms. In compound leaves the petiole is not only generally articulated to the stem, but the partial petioles are also frequently articulated to the rachis, so that each leaflet becomes detached separately from the common petiole when the leaf begins to decay, as in the Sensitive Plant. By many botanists, indeed, no leaf is considered truly compound unless it presents this characteristic, consequently all leaves however much divided, and apparently compound, but which have not their separate portions articulated, are considered simple. Such a distinctive character cannot however be well carried out in practice, and when we consider that the presence of an articulation is by no means constant even in simple leaves, I

can see no sufficient grounds for insisting upon this character in the separate portions of a leaf as evidence of its compound nature. The distinctive characters of simple and compound leaves as adopted by me, have been already treated of under the head of composition of leaves.

The presence of an articulation is to a certain extent a character of distinction between the three great classes of plants. Thus the leaves of Dicotyledonous Plants are in the majority of instances articulated; while those of Monocotyledonous, and Acotyledonous Plants are non-articulated. Hence the leaves of the latter when they have performed their functions, instead of falling away and leaving a cicatrix as the former, decay gradually upon their respective plants, to which they give a ragged appearance. There are many instances, however, in which the leaves of Dicotyledonous Plants are not articulated, as in the Oak, &c. In such cases, the leaves although dead, remain attached to their respective plants frequently for months, which thus form a striking contrast in their appearance to the surrounding trees, which have lost their leaves in consequence of being articulated.

Fig. 350.

Fig. 351.

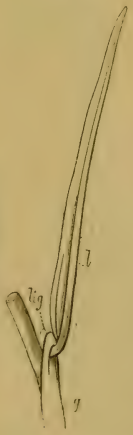


Fig. 350. A portion of a branch and leaf of the Sensitive Plant (*Mimosa pudica*), showing pulvinus at the base of the petiole, and struma at the base of the partial petioles. —— *Fig.* 351. Stem of a Grass with a leaf attached. *l.* Blade. *g.* Sheathing petiole. *lig.* Ligule.

On the lower surface of the petiole at its base, the parenchyma frequently forms a slight swelling (*figs.* 349, *c*, and 350), to which the name of *pulvinus* has been given. A somewhat similar swelling may be also seen in many compound leaves at the base of each partial petiole (*fig.* 350), which is termed the *struma*. The compound pinnate leaves of the Sensitive Plant afford a good illustration of the presence of both pulvinus and struma.

The form of the petiole varies; it is usually rounded below, and flattened, or more or less grooved above (*fig.* 311). In other cases it is cylindrical, especially in the leaves of Monocotyledonous Plants, while in other plants of the same class, especially in Grasses, it becomes widened at its base, and surrounds the stem in the form of a *sheath* or *vagina* (*figs.* 259 and 351, *g*). This sheath in all true

Grasses terminates above in a membranous appendage (*fig.* 351, *lig*), which is either entire, incised in various ways, or divided into two symmetrical portions; to this appendage the name of *ligule* has been given. It is supposed to be analogous to the stipules; the researches of De Mercklin on the development of leaves have not however enabled him to decide, whether the formation of the ligule is absolutely identical with that of stipules. In the Aspen (*Populus tremula*) the petiole is flattened in a line at right angles to the blade; this is the cause of the peculiar mobility of such leaves; in other plants it is flattened in a horizontal direction. In Water Plants the petiole is frequently more or less dilated from the presence of a number of air cavities, as in Pontederia, and Trapa; such petioles by diminishing the specific gravity of the plants enable them to float readily in the water. At other times it becomes dilated at its base, and embraces the stem, in which case the leaf is said to be *amplexicaul* (*fig.* 258); this commonly occurs in Umbelliferous Plants. Frequently it

Fig. 352.

Fig. 353.

Fig. 352. A portion of the stem with some leaves of Venus's Fly-trap (*Dionœa muscipula*). *l.* Lamina fringed with hairs, hence it is said to be ciliated. *p.* Winged petiole. —— *Fig.* 353. Decurrent leaves of the Comfrey (*Symphytum*).

presents at its two edges a leaf-like border called a *wing*; when it is said to be *winged* or *bordered;* examples of such a petiole occur in the Orange (*fig.* 300, *p*), Venus's Fly-trap (*fig.* 352, *p*), Sweet Pea (*fig.* 362), and many other plants. In the latter plant the winged expansion does not terminate at the base of

the petiole where it joins the stem, but it extends downwards along it; in which case the stem is also termed winged, and the leaf is said to be *decurrent* (*figs.* 260 and 353). Besides the above forms of petiole, others still more remarkable occur, which will be alluded to hereafter, under the head of Anomalous Forms of Leaves.

Generally speaking the petiole is less developed than the lamina or blade; it is also commonly shorter than it, and of sufficient thickness to support it without bending. When it is very long or thin, or when the lamina is very heavy, and in other cases, it becomes more or less bent downwards towards the earth, and no longer supports the lamina in a horizontal direction.

6. STIPULES.

Stipules are small leafy bodies situated at the base and usually on each side of the petiole (*fig.* 255, *s*, *s*). They have the same structure as leaves, and are liable to similar modifications as regards colour, texture, figure, venation, &c. The stipules are often entirely wanting, and the leaves are then said to be *exstipulate*; when present they are *stipulate*. They are often overlooked from their small size; while in other cases they are very large, as in the Pansy (*fig.* 356), and in the common Pea (*fig.* 354). In the leaves of *Lathyrus Aphaca* again (*fig.* 363), there are no true blades to the leaves, but the stipules are here very large and perform all their functions. It sometimes happens that the leaflets of a compound leaf possess little stipules of their own, as in the Bean. To these the name of *stipels* has been given, and the leaf is then termed *stipellate*.

Fig. 354.

Fig. 354. A portion of the flowering stem of the common Pea, with a pinnate leaf terminated by a tendril, and having two large stipules at its base, the lower margins of which are dentate.

Stipules either remain attached as long as the leaf, when they are said to be *persistent;* or they fall off soon after its expansion, in which case they are *deciduous.* In the Beech, the Fig, the Magnolia, &c., they form the *tegmenta* or protective coverings of the buds, and fall off as those open.

The stipules vary in their position with regard to the petiole and to each other, and have received different names accordingly. Thus, when they adhere on each side to the base of the petiole, as in the Rose (*fig.* 355), they are said to be *adnate,*

Fig. 355.

Fig. 356.

Fig. 355. A portion of a branch, *r*, of the common Rose (*Rosa canina*). *a.* A prickle. *b.* Bud in the axil of a compound leaf *f.* *p.* Petiole. *s.* Adnate or adherent stipules.——*Fig.* 356. Leaf of Pansy (*Viola tricolor*) with large caulinary stipules at its base.

adherent, or *petiolar.* When they remain as little leaflets on each side of the base of the petiole, but quite distinct from it, as in many Willows (*fig.* 255), and Pansy (*fig.* 356), they are called *caulinary.* When the stipules are large, it sometimes happens that they meet on the opposite side of the stem from which the leaf grows, and become united by their outer margins, and thus form one stipule, as in the Astragalus and Plane-tree, they are then said to be *synochreate,* or *opposite* (*fig.* 357); if under similar circumstances they cohere by their inner margins, as in *Melianthus annuus,* and *Houttuynia cordata* (*fig.* 358), they form a solitary stipule which is placed in the axil of the leaf, and is accordingly termed *axillary;* if such stipules cohere by both

Fig. 357.

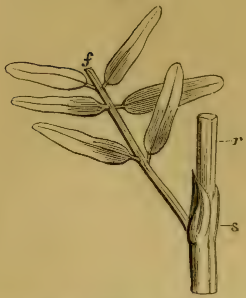


Fig. 358.

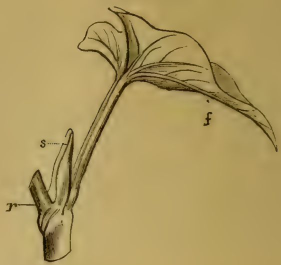


Fig. 357. A portion of the stem *r*, and leaf *f*, of the *Astragalus Onobrychis*. *s*. Synochreate or opposite stipules.——*Fig.* 358. A portion of the stem *r*, and leaf *f*, of *Houttuynia cordata*. *s*. Axillary stipule.

outer and inner margins so as to form a sheath which encircles the stem above the leaf (*fig.* 254), as in the Rhubarb, and most Polygonaceæ, they form what is termed an *ochrea* or *intrafoliaceous* stipule. All the above forms of stipules occur in plants with alternate leaves, in which these appendages are far more common than in those with opposite leaves. When the latter have stipules it generally happens that these are situated in the intervals between the petioles on each side, and are hence termed *interpetiolar*. In such cases, one of the stipules of each leaf on the two sides of the stem frequently cohere by their outer margins more or less completely, so as to form but one interpetiolar stipule on each side of the stem (*fig.* 359), as is the case

Fig. 359.

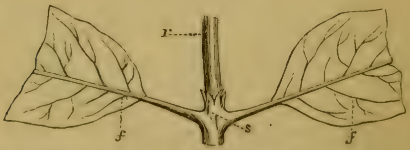


Fig. 359. A portion of a branch *r*, with two opposite leaves *f f*, of *Cephalanthus occidentalis*. *s*. Interpetiolar stipule.

in the Cinchonas, the Coffee, and other plants of the order to which they belong.

Stipules, as we have already noticed, are not always present in plants, but their presence or absence in any particular plant is always regular, and although the appearance and arrange-

ment of them also vary in different plants, they are always uniform in those of the same species, and even in some cases, throughout entire natural orders, and thus they frequently supply important distinctive characters in such plants and orders. Thus the Cinchonaceæ is distinguished from the allied order Caprifoliaceæ by possessing interpetiolar stipules; and the Polygonaceæ from its allied orders by intrafoliaceous stipules.

Stipules are very rare in Monocotyledons, except the ligule of Grasses be considered as analogous to them (*fig.* 351). The only orders of Monocotyledons in which they undoubtedly occur, are the Naiadaceæ and Araceæ.

The flat dilated portion at the base of many petioles, as in the Umbelliferæ (*fig.* 258), is by some botanists regarded as formed by adherent stipules; this part is sometimes called the *pericladium*. The fibrous sheath at the base of the leaves of Palms, which is called the *reticulum*, is by some also thought to be a stipular appendage.

7. ANOMALOUS FORMS OF LEAVES.

We have already seen that the branches of a stem sometimes acquire an irregular development, and take the form of Spines and Tendrils (see page 109). In the same manner, the leaf, or its parts may assume similar modifications, as well as some others still more remarkable, which we now proceed to describe.

Fig. 360.

Fig. 360. A portion of a branch of the Barberry (*Berberis vulgaris*), bearing spiny leaves. The upper leaf is composed entirely of hardened veins, without any parenchyma between them.

Spines of Leaves.—Any part of the leaf may exhibit a spiny character owing to the non-development, or diminution of parenchyma, and the hardening of the veins. Thus,—1st, In the Holly (*fig.* 302), and many Thistles (*fig.* 260), the veins project beyond the blade, and become hard and spiny; in some Solana, the spines are situated on the surface of the blade; while in the Barberry (*fig.* 360) the blade has little or no parenchyma produced between its veins, which are of a spiny character, so that the whole blade becomes spinous. These spines may be readily distinguished from those already described which are modified branches, because in the latter case they always arise from the axil of the leaf, instead of from the leaf itself. Spines may also be readily distinguished from prickles by their internal structure and other

Fig. 361.

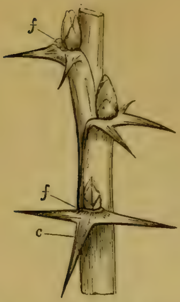


Fig. 361. A portion of a branch of the Gooseberry (*Ribes Grossularia*). *f, f*. Scars of leaves, with buds in their axils. c. Spines produced from the pulvinus.

characters alluded to when speaking of the spines of branches. 2nd, The petiole may assume a spiny character, either at its apex, as in *Astragalus Tragacantha* and *massiliensis;* or at its base by the pulvinus (*fig.* 361), as in *Ribes Grossularia.* 3rd, The stipules may become transformed into spines, as in the False Acacia (*Robinia pseudo-acacia*), (*fig.* 256).

Tendrils of Leaves.—Any part of the leaf may also become cirrhose or transformed into a tendril. Thus, — 1st, The midrib of the blade of a simple leaf may project beyond the apex, and form a tendril, as in *Gloriosa superba*, and *Albuca cirrhata ;* or in other cases some of the leaflets of a compound

Fig. 362.

Fig. 364.

Fig. 363.

Fig. 362. Leaf of *Lathyrus*, showing a winged petiole, with two half-sagittate stipules at its base, and terminated by a tendril. —— *Fig.* 363. A portion of the stem of *Lathyrus Aphaca*, with stipules *s*, and cirrhose tendril *v*. —— *Fig.* 364. A portion of the stem of *Smilax*, bearing a petiolar leaf, and two tendrils in place of stipules.

leaf may become transformed into branching tendrils (*figs.* 354 and 362), as in *Lathyrus sylvestris* 2nd, The petiole may become cirrhose, as in *Lathyrus Aphaca* (*fig.* 363), and many other plants of the Leguminosæ. 3rd, The stipules may assume the form of tendrils : thus in many species of Smilax, there are two tendrils, one on each side of the petiole (*fig.* 364) ; in the Melon, Cucumber, and some other plants of the Cucurbitaceæ there is but one tendril at the base of each leaf.

Phyllodes or Phyllodia.—In the leaves of some plants, as in Australian Acacias (*fig.* 365), &c., the vascular bundles of the petiole, instead of remaining till they reach the blade before se-

Fig. 365.

Fig. 366.

Fig. 365. A phyllode of an Australian Acacia.——*Fig.* 366. Leaf of an Acacia (*Acacia heterophylla*), the petiole of which assumes the character of a phyllode, and is terminated by a bipinnate lamina. The venation of the phyllode may be seen to be parallel.

parating, begin to diverge as soon as they leave the stem and become connected by parenchyma as in the ordinary blade of a leaf ; the petiole thus assumes the appearance of a lamina, and

performs in such a case all its functions. To such a petiole the name of *phyllodium* or *phyllode* has been applied. In some cases, as in *Acacia heterophylla*, the phyllode is terminated by a true blade (*fig.* 366), and its nature is thus clearly ascertained, but in other instances no blade is produced (*fig.* 365), and such plants are commonly termed leafless. These phyllodes may be distinguished from true blades, not only by the frequent production of a lamina (*fig.* 366), but also by other circumstances. Thus,—1st, By their venation, which is more or less parallel (*fig.* 366) instead of reticulated, as is the case generally in Dicotyledonous Plants in which they alone occur. 2nd, By their being placed nearly or quite in a vertical direction—that is turning their margins instead of their surfaces to the earth and heavens. And 3rd, By their two surfaces resembling each other, whereas in true blades a manifest difference is commonly observable between the upper and lower surfaces. Trees presenting this character in their petioles are very common in Australia, and give a very peculiar character to the vegetation of that country by the singular distribution of light and shade which they produce, as was first noticed, and the cause ascertained by that most acute botanist Robert Brown.

Besides the true phyllodes thus described, there are however some others, which are generally considered as such by botanists, which do not possess such well marked distinctive characters, as the leaves of some species of Ranunculus, &c. In these phyllodes the direction is horizontal as in true blades, and in some other respects they resemble them; they have however parallel venation instead of reticulated, and belonging to Dicotyledonous Plants, this character will suffice to distinguish them, as it is now become the general rule of botanists to consider all organs occupying the place of leaves among Dicotyledons which are not reticulated, as phyllodes.

Ascidia or Pitchers.—These are the most remarkable of all the anomalous forms presented by leaves. They may be seen in the Pitcher plants, as *Nepenthes distillatoria* (*fig.* 367), in the Side-saddle plant (*Sarracenia purpurea*) (*fig.* 368), in the *Dischidia Rafflesiana*, and in many others. These curious organs may be either formed from the petiole or the blade of the leaf. Thus, in Sarracenia (*fig.* 368), the pitcher appears to be produced by the folding inwards of the two margins of a phyllode, which unite below, and form a hollow body or pitcher, but which are still separate above, and thus indicate its origin. The origin of the pitcher from the phyllode is however probably best seen in a species of Heliamphora (*fig.* 369) described by Mr. Bentham, in which the union of the margins of the phyllode is even less evident than in the Sarracenia. In the Nepenthes (*fig.* 367), the petiole first expands into a phyllode, then assumes the appearance of a tendril, and ultimately forms a pitcher, which is closed above

Fig. 367.

Fig. 368.

Fig. 369.

Fig. 367. Pitcher of a species of Pitcher plant (*Nepenthes distillatoria*). *p.* Pitcher closed above by a lid, *l.* —— *Fig.* 368. Pitcher of a Side-saddle plant (*Sarracenia purpurea*). —— *Fig.* 369. Pitchers of *Heliamphora.*

by a lid called an operculum, united to it by an articulation. The lid is here regarded as a remarkable transformation of the blade. This kind of pitcher is looked upon by some botanists as a modification of such leaves as the Orange (*fig.* 300), and Venus's Fly-trap (*fig.* 352), in which the petiole is articulated to the blade ; thus, if we suppose the winged petiole of such plants to fold inwards and unite by its margins a pitcher would be formed resembling that of Nepenthes, and the jointed blade would then be seen to be clearly analogous to the operculum or lid of that plant. According to Griffith, the pitcher of Nepenthes is a modification of the excurrent midrib or the stalk of the pitcher, and Dr. Hooker has recently confirmed his observations, and shown that it is formed out of a gland situated at the apex of the midrib. In the Dischidia, the pitchers are considered to be formed by the folding inwards and union of the margins of the laminæ or blades. Other botanists consider the pitchers of Nepenthes and Sarracenia as petioles hollowed out towards their extremities, but the opinions given above as to their origin appear far more likely, and conformable to observation in other cases.

8. GENERAL VIEW OF THE LEAVES IN THE THREE GREAT CLASSES OF PLANTS.

We have already seen in describing the structure and general characters of the stems and roots, that they present well marked distinctive characters in the three great classes of plants. We

have now to describe generally the distinctive characters of the leaves in those three great divisions.

1. Leaves of Dicotyledonous Plants.—In these the venation is reticulated in consequence of the veins branching in various directions and becoming united with each other, so as to form an angular network (*fig.* 291). In some plants, as in *Ranunculus Lingua*, *gramineus*, &c., the so called leaves have parallel veins, and have been therefore considered by some botanists as presenting exceptions to the ordinary reticulated venation of Dicotyledons, but these as we have seen, are not true leaves, but phyllodes or transformed petioles.

The leaves of Dicotyledons are very commonly articulated to the stem, often compound, and variously toothed or incised at their margins.

2. Leaves of Monocotyledonous Plants.—In these the venation is commonly more or less parallel: either from base to apex (*fig.* 290, *a*); or presenting one large central vein from which secondary veins are given off, which proceed in a parallel direction to the margin, as already described in the Banana, &c. (*fig.* 290, *b*). The leaves of plants belonging to the Natural orders, Smilaceæ (*fig.* 364), Dioscoreaceæ, and Trilliaceæ, as well as some in the order Araceæ, present exceptions to this character, for in them the veins branch in various directions and form a network, as in the leaves of Dicotyledons. Some of these plants, as the Dioscoreaceæ, Smilaceæ, and Trilliaceæ, have been therefore separated from the class of Monocotyledons by Lindley, and placed in one by themselves, called Dictyogens, from the Greek word, signifying a net. We have already seen that such plants also present certain differences in their stems from those of Monocotyledonous Plants generally.

In Monocotyledonous Plants the leaves are not articulated; their margins are usually entire or free from toothings and incisions of every kind. They are also commonly simple. Their leaves are often sheathing at the base; and seldom have stipules, unless the ligule is to be considered as analogous to them.

3. Leaves of Acotyledonous Plants.—In plants of this class which have leaves with a true fibro-vascular system or veins, these are arranged at first, either in a pinnate or palmate manner, but the extremities are always bifurcated or forked (*fig.* 299). The leaves of ferns are commonly called *fronds*.

Such leaves are usually not articulated; either sessile, or stalked; frequently toothed, or incised in various ways; and often highly compound.

9. DEVELOPMENT OF LEAVES.

Nearly all that we know upon the Development of Leaves is due to the admirable investigations of De Mercklin and

Trecul, and we shall content ourselves therefore in giving a general abstract of their views upon this subject. The following is a summary of De Mercklin's conclusions from Lindley's Introduction to Botany :—

"All leaves are produced on an axis, and their first form is that of a tumour. The lobes, segments, or leaflets on the lower half of a completely formed leaf, are produced from the axis, after the lobes, segments, or leaflets on the upper half.

The original tumour corresponds with the apex of the leaf, or with the summit of the common petiole.

In all leaves, the blade and top of the petiole are formed before the stipules and the lower part of the petiole.

The formation of compound leaves consists of two stages : first that of a simple leaf ; then that of a pinnate leaf. It is not very probable that the second owes its origin to the axis of the leaf bud as the first does. The petiole (either of a simple or of a compound leaf) ought, whether we regard its position relative to the axis or its anatomical structure, to be considered as an immediate elongation of the axis ; it certainly has a great influence on the formation of the leaf.

The stipel is formed after the point of the leaflet which it accompanies ; its development is generally much slower than that of a stipule.

All the parts of a leaf are symmetrical from their birth, and the rudiment of each leaf is a body symmetrical in its relation to the axis.

The young leaflets of all compound leaves are always opposite.

All the parts of a rudimentary leaf are capable of development. This development generally proceeds from the apex to the base of the leaf, and is greater and stronger towards the latter. The development takes place in all directions, and predominates in determinate directions.

The blade of a leaf is first developed. Leafy lamellæ are extensions of it, whether they are equilateral or inequilateral.

Teeth and crenels appear to be owing to the development of certain series of cellules from the edge of a leaf. No trace of them is to be found in very young leaves, the blades of which are beginning to be formed.

Stipules of Dicotyledons, in consequence of the great longitudinal development of the petiole, appear as organs distinct from the blade. The rapidity of their development is probably due to their proximity to the axis. Their blade is developed, covering the axis or other organs.

The petiole is principally developed in one direction ; of all the parts of a leaf, it is that which grows the most in proportion to its original size.

Although most of these views are founded on facts, yet they

want an absolutely certain basis, which cannot be obtained without observing the internal life of the parenchyma of the leaf and of its products. This ought to remain the object of a true history of the development of leaves ; for at present their successive transformations only have been observed."

The following is an abstract of Trecul's conclusions, as given by Balfour in his Class Book of Botany :—

"All leaves originate in a primary cellular mammilla, with or without a basal swelling, according as they are to have sheaths or not ; they are developed after 4 principal types—1, the *centrifugal* formation, from below upwards ; 2, the *centripetal* formation, from above downwards; 3, the *mixed* formation ; and 4, the *parallel* formation. The *centrifugal* development may be illustrated by the leaf of the Lime-tree, which begins as a simple tumour at the apex of the stem. This tumour lengthens and enlarges, leaving at its base a contraction which represents the petiole. The blade, at first entire, is soon divided from side to side by a sinus. The lower lobe is the first secondary vein. The upper lobe is divided in the same manner 5 or 6 times, forming as many secondary veins. Sinuosities then appear in the lower lobe, indicating the ramifications of the lower vein ; and finally fresh toothings appear corresponding with more minute ramifications. Thus the various veins in the leaf of the Lime-tree are developed like the shoots of the tree that bears them, and the toothing does not arise from cells specially adapted for that purpose on the edge of the leaf, as Mercklin has supposed. The hairs on the under surface of the leaf are also formed from below upwards.

Leaves developed *centripetally* are equally numerous with the preceding ; of this sort are the leaves of *Sanguisorba officinalis*, *Rosa arvensis*, *Cephalaria procera*, &c. In them the terminal leaflet is first produced, and the others appear in successive pairs downwards from apex to base. The stipules are produced before the lower leaflets. All digitate leaves, and those with radiating venation belong to the centripetal mode of formation as regards their digitate venation.

In some plants, as Acer, the two preceding modes of development are combined. This is called *mixed formation*. In *Acer platanoides* the lobes and the midribs of the radiating lobes form from above downwards, the lower lobes being produced last, but the secondary venations and toothings are developed like those of the Lime-tree. In Monocotyledons we meet with the *parallel leaf formation* of Trecul. All the veins are formed in a parallel manner, the sheath appearing first. The leaf lengthens especially by the base of the blade, or that of the petiole when present.

Leaves furnished with sheaths, or having their lower portions protected by other organs, grow most by their base ; while those

which have the whole petiole early exposed to the air, grow much more towards the upper part of the petiole."

It will be seen that the above results of M. Trecul differ in several important particulars from those of De Mercklin, and that the development of leaves is by no means such a simple and uniform process as was supposed by him. Further investigations are however still required before we can be said to have arrived at altogether certain conclusions upon the subject.

For further observations on this subject the reader may consult, *De Mercklin Observations sur l'Histoire du Développement des Feuilles. Annales des Sciences Nat. Bot.* 3d ser. vi. 215 ; and *Trecul, Comptes Rendus* for 1853.

CHAPTER 4.

ORGANS OF REPRODUCTION.

Under the head of Organs of Reproduction we include the flower and its appendages ; and they are so called, because they have for their office the reproduction of the plant by the formation of seed. Plants with conspicuous organs of reproduction are called *Phænogamous*, *Phanerogamous*, or *Flowering;* while those in which these parts are concealed or obscure, are termed *Cryptogamous* or Flowerless. The former division includes Dicotyledonous and Monocotyledonous Plants ; the latter Acotyledonous Plants.

The parts of a flower (as will be particularly shown hereafter) are only leaves in a modified condition adapted for special purposes ; and hence a flower in an unexpanded state or a flower-bud is analogous to a leaf-bud, and the flower itself therefore to a branch the internodes of which are but slightly developed, so that all its parts are situated in nearly the same plane. As flower-buds are thus analogous to leaf-buds they are subject to similar laws of arrangement and development.

Section 1. Inflorescence or Anthotaxis.

The term *inflorescence* is applied generally to indicate the floral axis and its ramification, or the arrangement of the flowers upon that axis. Under this head we have to examine — 1st, The Leaf from the axil of which the flower-bud arises ; 2nd, The Stalk upon which the flower is situated ; and 3rd, The Kinds of Inflorescence.

1. Floral Leaves or Bracts.—We have already stated

that flower-buds are analogous to leaf-buds ; and this analogy is still farther proved by their occupying similar situations to them ; thus, they are placed either at the apex of the floral axis or branch, or in the axil of leaves. Flower-buds, therefore, like leaf-buds, are terminal or axillary. In the latter case the leaves from which they arise are called *bracts* or *floral leaves.* In strict language the term bract should be only applied to the leaf from the axil of which the floral axis arises, while all other leaves which are found upon that axis between the bract and the flower properly so called, should be termed *bractlets* or *bracteoles.* These two kinds are however but rarely distinguished in practice, the term bract being generally used to indicate either, and in this sense we shall hereafter apply it.

Bracts vary much in appearance, some of them being large, of a green colour, and in other respects resembling the ordinary leaves of the plant upon which they are placed, as in the White Dead-nettle (*Lamium album*) (*fig.* 370); and in the

Fig. 370.

Fig. 370. Flowering stalk of the White Dead-nettle (*Lamium album*).

Pimpernel (*Anagallis arvensis*) (*fig.* 371); in which case they are called *leafy bracts.* Such bracts can only be distinguished from the true leaves by their position with regard to the flower-stalk or flower. In most cases however, bracts may be known

Fig. 371. Fig. 372. Fig. 373.

Fig. 371. Flowering stalk of the Pimpernel (*Anagallis arvensis*). *b.* Solitary flowers arising from the axil of the bracts, *a.* —— *Fig.* 372. Flower of Marsh-Mallow (*Althæa officinalis*) surrounded by an epi-calyx or involucre. —— *Fig.* 373. Flower of Strawberry (*Fragaria vesca*), surrounded by an epi-calyx or involucre.

from the ordinary leaves not only by their position, but also by differences of colour, outline, and other particulars. Sometimes when the bracts are situated in a whorl immediately below the calyx or outer covering of the flower, it is difficult to determine whether they should be considered as a part of the calyx or as true bracts ; thus in the Mallow tribe (*fig.* 372), many of the Pink tribe, and Rose tribe (*fig.* 373), we have a circle of leafy organs placed just below the calyx, to which the term of *epicalyx* has been given by many botanists, but which properly comes under the denomination of involucre (page 190).

Almost all inflorescences are furnished with bracts of some kind or other ; it frequently happens, however, that some of them do not develop flower-buds, just in the same manner as it occasionally happens that the leaves do not produce leaf-buds in their axils. In some cases the non-development of flower-buds in the axil of bracts appears to arise simply from accidental causes ; but in others, it occurs as a regular law, thus in the Purple Clary (*Salvia Horminum*) and common Pine-apple there are a number of bracts without flower-buds placed at the apex of the inflorescence. Bracts from which flower-buds do not arise are called *empty*. When bracts are absent altogether, as in the plants of the natural order Cruciferæ, and commonly in the Boraginaceæ, such plants are said to be *ebracteated*.

Bracts follow the same law of arrangement as true leaves, being opposite, alternate, or whorled, &c., in different species. The bracts of the Pine-apple fruit (*fig.* 706, 2) and those of

Fir cones (*figs.* 269 and 397) show in a marked manner a spiral arrangement.

Bracts vary in their duration ; when they fall immediately, or soon after the flower-bud expands, they are said to be *deciduous.* When they remain long united to the floral axis, they are *persistent.* In some plants, they remain and form a part of the fruit; thus, in the Nut and Filbert they form the husk (*fig.* 378), in the Acorn they constitute the cup (*fig.* 377), and in the Hop-fruit (*fig.* 398), in the Fir-cones (*figs.* 269 and 397), and Pine-apple (*fig.* 706, 2), they persist as membranous, woody, or fleshy scaly appendages.

Certain varieties of arrangement and forms of bracts have received special names. Thus the bracts of that kind of inflorescence called an Amentum or Catkin (*fig.* 374), as in the Willow, Oak, Birch, &c., are termed *squamæ* or *scales.*

Fig. 375.

Fig. 374.

Fig. 374. Male catkin of the Hazel, showing a number of scaly bracts between the flowers.—— *Fig.* 375. Compound umbel of the Carrot (*Daucus Carota*). *a.* General involucre. *b.* Partial involucre.

When a circle or whorl of bracts is placed round one flower, as in the Mallow (*fig.* 372) and Strawberry (*fig.* 373), or a number of flowers, as in the Carrot (*fig.* 375), and many umbelliferous plants, they form what is termed an *involucre.* In some umbelliferous plants, as for instance the Carrot (*fig.* 375), there are two kinds of involucre, one at the base of the primary divisions of the floral axis or general umbel (*a*); and another at the base of each of the partial umbels or umbellules (*b*); the former is then called the *general involucre;* and each of the latter an *involucel* or *partial involucre.* In plants of the natural order Compositæ, as the Marygold (*fig.* 376), Artichoke,

Chamomile, Daisy, &c., and in some allied orders, a somewhat similar arrangement of bracts takes place, and the name of *involucre* is also applied to them. In these cases there are frequently two or three rows of bracts overlapping each other. The bracts thus forming the involucre of Composite flowers have been termed *phyllaries*. Sometimes the bracts of an involucre grow together at their base, and form ultimately a sort of cup-shaped body surrounding the fruit, as the cup of the Acorn (*fig.* 377), and the husk of the Filbert or Hazel-nut (*fig.* 378); they then form what is called a *cupule*.

Fig. 376.

Fig. 376. Capitulum of Marygold (*Calendula*), showing the flowers enclosed in an involucre.

Fig. 377.

Fig. 378.

Fig. 377. Fruit of the Oak (*Quercus pedunculata*) surrounded by a cupule. —— *Fig.* 378. Fruit of the Hazel (*Corylus Avellana*) with cupule at the base.

Fig. 380. *Fig.* 379.

Fig. 379. Flower of the Spring Snow-flake (*Leucojum vernum*). —— *Fig.* 380. Spadix of Cuckow-pint (*Arum maculatum*), enclosed in a spathe.

When a bract is of large size and sheathing, and surrounds one, or a number of flowers, so as to completely enclose them when in a young state, as in the Iris, Narcissus, Snow-flake (*Leucojum vernum*) (*fig.* 379), the common Arum (*Arum maculatum*) (*fig.* 380), and Palms (*fig.* 394), it is called a *spathe;* this is very common in Monocotyledonous Plants, and also generally surrounds the kind of inflorescence called a spadix, as in the Arum (*fig.* 380). The spathe may be either green like an ordinary leaf, or coloured as in *Richardia æthiopica.* In some Palms these spathes are of great length, thus, as much as twenty feet; and as many as 200,000 flowers have been counted in some of them. Sometimes the spadix of Palms branches (*fig.* 394), and then we frequently find smaller spathes surrounding the divisions, which have been named *spathellæ.*

Besides the bracts which surround the head of flowers of the Compositæ and form an involucre, it frequently happens that the individual flowers are also provided with little bracts, which are then generally of a membranous nature, and colourless, as in the Chamomile (*fig.* 381); these have received the name of *paleæ.*

The only other bracts which have received special names are those found in Grasses, and Sedges. Thus, the partial inflorescence of a Grass which is termed a *locusta* or *spikelet,* has at its base, one, or two bracts, to which the name of *glumes* has been given (*fig.* 382, *gl, gl*). In the Cyperaceæ each flower is surrounded by similar bracts. In the Grasses also, we find that

Fig. 382.

Fig. 381.

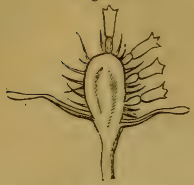


Fig. 381. Receptacle of Chamomile (*Anthemis nobilis*) bearing flowers and bracts, which are sometimes termed *paleæ*. The receptacle is here drawn much too large at the apex, it should be conical.——*Fig.* 382. Locusta or spikelet of the Oat (*Avena sativa*). *gl, gl.* Glumes. *ps, pi. Paleæ. a.* Awn arising from the dorsum of the outer palea, *ps. fs.* An abortive flower.

each flower has two other bracts (*fig.* 382, *ps, pi*), which are commonly called *paleæ;* and also frequently at the base of the ovary (*fig.* 586, *sp*), two or more little scales, also of the nature of bracts, which are generally termed *squamulæ*, *glumellules*, or *lodiculæ*.

2. The Peduncle or Flower-stalk.—This term is applied to the stalk of a solitary flower, whether axillary or terminal (*figs.* 371 and 379), or to a floral axis which bears a number of sessile flowers (*figs.* 374 and 376), or if the floral axis branches and each branch bears a flower (*fig.* 399), the main axis is still called a *peduncle*, and the stalk of each flower a *pedicel*, or if the axis be still further subdivided, the general name of peduncle (*fig.* 401) is applied to the whole, with the exception of the stalks immediately supporting the flowers, which are in all cases called pedicels. When the floral axis is thus branched, it is better to speak of the main axis as the *primary* axis (*fig.* 412, a'), its divisions as the *secondary* axes a'', and their divisions as the *tertiary* axes a''', &c.

Under certain circumstances peduncles have received special names. Thus, when a peduncle is elongated, and gives off from its sides sessile flowers (*fig.* 391), or branches bearing flowers (*fig.* 399), it is called the *rachis* or *axis*. When the peduncle instead of being elongated in a longitudinal direction, becomes shortened and dilated more or less horizontally, and bears numerous flowers, it is called the *receptacle*, or by some *clinanthium* or *phoranthium*. The receptacle varies in form, sometimes it is

flattened, as in the Cotton Thistle (*Onopordum Acanthium*) (*fig.* 404); or it is conical, as in the Chamomile (*fig.* 381); or concave, as in the Dorstenia (*fig.* 384); or pear-shaped, as in the Fig (*fig.* 383); or it assumes a variety of other intermediate

Fig. 383.

Fig. 384.

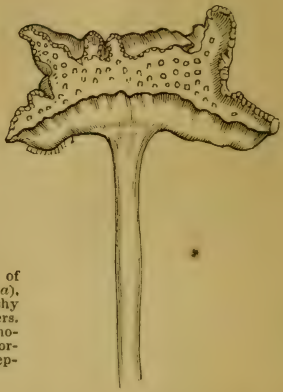


Fig. 383. Hypanthodium of the Fig (*Ficus Carica*), showing pear-shaped fleshy receptacle bearing flowers. —— *Fig.* 384. Hypanthodium of a species of Dorstenia, with concave receptacle.

forms. It should be particularly observed, that the term receptacle is also applied by some botanists to the apex of the peduncle or pedicel, whether enlarged or not, and whether bearing one or a number of flowers. When plants which have no aerial stems bear flowers, the peduncle necessarily arises at, or under the ground, in which case it is called a *Scape* or *radical peduncle* (*fig.* 379), as in the Spring Snow-flake, Tulip, Hyacinth, Primrose, Cowslip, &c.

In form the peduncle is generally more or less cylindrical, but besides the departure from this ordinary appearance as exhibited by the receptacle just described, it frequently assumes other forms. Thus, it may become more or less compressed, or grooved in various ways, or it may become excessively enlarged during the ripening of the fruit, as in the Cashew Nut; or it may assume a spiral appearance, as in the Vallisneria (*fig.* 385); or become spiny, or transformed into a tendril, &c. In the Eschscholtzia it becomes hollowed out at its apex, so as to form a cup-shaped body, to which the lower part of the calyx is attached.

In some cases the peduncle becomes flattened and assumes the form of a phyllode, in which case it is called a *phylloid peduncle* or

pedicel. Examples of this occur, in the Butcher's-Broom (*Ruscus aculeatus*) (*fig.* 386), where the flowers arise from its surface,

Fig. 385.

Fig. 386.

Fig. 385. Female plant of *Vallisneria spiralis*, with its flowers arranged on spiral peduncles. —— *Fig.* 386. Portion of a branch of the Butcher's-Broom (*Ruscus aculeatus*), with phylloid pedicels bearing flowers *a*.

and in Xylophylla, in which the flowers are attached to its margins. Sometimes the peduncle, or several peduncles united, assume an irregular flattened appearance, somewhat resembling a fasciated branch already described, and bear numerous flowers in a sort of crest at their extremities, as in the Cock's-comb.

In speaking of the branches of a stem, we found that in some cases instead of arising in the axil of leaves, they became *extra-axillary*, in consequence of adhesions of various kinds taking place between them and the stem, &c. In like manner the peduncle may become *extra-axillary* by contracting adhesions. Thus, in the Lime tree (*Tilia europæa*) (*fig.* 387), the peduncle adheres to the midrib of the bract for some distance, and then becomes free. In many Solanaceæ (*fig.* 388), the peduncle also becomes extra-axillary by forming adhesions to the stem in various ways.

With respect to their duration the peduncle and pedicel vary. Thus, they are said to be *caducous*, when they fall off soon after the opening of the flower, as in the staminiferous or male flowers of a catkin; they are *deciduous*, when they fall off after the fruit has ripened, as in the Cherry; they are *persistent* if they remain after the ripening of the fruit and dispersion of the seed, as in the Dandelion; or if they enlarge or continue to grow during

Fig. 387. *Fig.* 388.

Fig. 387. Peduncle of the Lime tree (*Tilia europœa*) attached to bract *b*.——*Fig.* 388. Branch of Woody Nightshade (*Solanum Dulcamara*) with extra-axillary peduncle.

the ripening of the fruit, as in the Cashew Nut, they are *excrescent.*

3. Kinds of Inflorescence.—Flowers are variously arranged upon the floral axis, and to each mode of arrangement a particular name is applied. These modifications are always the same for the same species of plant, and frequently throughout entire genera, and even natural orders, and hence their discrimination is of great practical importance. All the regular forms may be arranged in two great classes, the principles of which being understood, their subordinate modifications will be readily intelligible. These two are called: 1st, *Indefinite* or *Indeterminate*, and 2nd, *Definite* or *Determinate Inflorescence.* In the former, the primary floral axis is terminated by a growing point, analogous to the terminal leaf-bud of a stem, or branch, and hence such an axis has the power of growing or elongating in an upward direction, or of dilating more or less horizontally, in the same manner as the terminal leaf-bud of a stem has the power of elongating, and thus adding to its length. There is consequently no necessary limit to the growth of such an axis, and hence the names of Indeterminate or Indefinite which is applied to it. Such an axis as it continues to grow upwards developes on its sides other buds, from which flowers

are produced, and these, like those of a branch, are developed in the axil of leaves called bracts, as we have before seen. All the flowers therefore of an Indefinite Inflorescence must be necessarily *axillary*, and hence such an inflorescence is also termed *axillary*. The general characters of Indefinite, Indeterminate, or Axillary Inflorescence depend therefore upon the indefinite growth of the primary axis, while the secondary, tertiary, or other axes which are developed from it, are terminated by flower-buds. In the *Definite* or *Determinate Inflorescence* on the contrary, the primary axis is terminated at an early period by the production of a flower-bud, such an axis has therefore a limit at once put to its growth in an upward direction, and hence the names of Definite, Determinate, or Terminal applied to it. Each of these classes of inflorescence presents us with several modifications, which we now proceed to describe.

1. Indefinite, Indeterminate, or Axillary Inflorescence.—The simplest kind of inflorescence in this class is that presented by such plants as the Pimpernel (*Anagallis arvensis*) (*fig.* 371), Money-Wort (*Lysimachia Nummularia*), in which solitary flowers are developed in the axils of the ordinary leaves of the plant, the primary axis continuing to elongate in an upward direction and bearing other leaves and flowers. The flowers are then said to be *solitary* and *axillary*. When such flowers are arranged in whorls round the stem, as in the common Mare's Tail (*Hippuris vulgaris*), each flower being axillary to a leaf (*fig.* 389), they are said to be *whorled*.

Fig. 389.

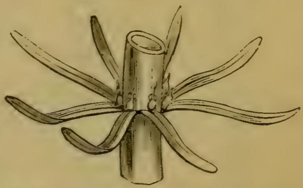


Fig. 389. Whorled leaves or bracts and flowers of Mare's Tail (*Hippuris vulgaris*).

When a number of flowers are developed instead of a single one upon an elongated or depressed axis, which is placed at the extremity of a branch, or in the axil of a bract, a number of kinds of inflorescence arise ; depending upon the extent to which the axis is divided, the mode in which the branching takes place, the comparative lengths of the flower-stalks, and other subordinate circumstances. It will be convenient to describe these various modifications under two heads. 1st, Those kinds of Indefinite Inflorescence with an Elongated Primary axis, and 2nd, Those with a Shortened or Dilated Primary axis.

1. *Kinds of Indefinite Inflorescence with an Elongated Primary Axis.*—These are as follows :—

a. *The Spike.*—This is a kind of inflorescence in which the primary elongated axis simply bears sessile flowers, or flowers

Fig. 390.

Fig. 391.

Fig. 390. Spike of a species of Rib-grass (*Plantago*). —— *Fig.* 391. Spike of Vervain (*Verbena*). The flowers at the base have already passed into the state of fruit, whilst those at the apex are still unexpanded.

in which the pedicels are very short, so as not to be clearly distinguishable. Examples of it may be seen in the Rib-grass (*Plantago*) (*fig.* 390), and Vervain (*Verbena officinalis*) (*fig.* 391). In this kind of inflorescence it will be observed that the flowers at the lower part of the spike are in fruit, while those near the middle are in full flower, and those at the top are still undeveloped. The flowers here therefore, open first at the base, and last at the apex. Such a mode of opening is called *centripetal.* This mode of expansion is universal in the different kinds of indefinite inflorescence, which in all cases open from the base to the apex if the axis is elongated (*fig.* 391), or from the circumference towards the centre if it is depressed or dilated (*fig.* 405). This centripetal order of expansion necessarily arises from the mode of development of such kinds of inflorescence; thus, the flower-buds which are situated at the base, are those which are first formed and which are consequently the oldest; as the axis elongates upwards, it is continually producing other flower-buds, the age of which continues to decrease as we approach the growing point or apex; and as flower-buds are necessarily most developed in the order of their age, it follows that those at the base will open first, and that the order of expansion will proceed gradually upwards towards the apex, or *centripetally.* Hence all indefinite inflorescences have a centripetal order of expansion.

There are five other kinds of indefinite inflorescence which are simply modifications of the spike. These are the Amentum or Catkin, the Spadix, the Locusta, the Cone, and the Strobile.

b. *The Amentum or Catkin.*—This is a kind of spike which only bears barren flowers—that is, only stamens (*fig.* 393), or pistils (*fig.* 392); these are separated from each other by squamous

Fig. 392.

Fig. 393.

Fig. 392. Pistillate amentum or catkin of a species of Willow (*Salix*).—— *Fig.* 393. Staminate amentum of Willow.

bracts, and the whole inflorescence usually falls off in one piece, soon after flowering, or fruiting; this is especially the case with the staminiferous-flowered catkin. All plants with this kind of inflorescence are called *amentaceous* or amentiferous. Our trees afford us numerous examples, as the Oak, the Willow, the Birch, the Poplar, the Walnut, &c.

c. *The Spadix* is a spike with a succulent axis, in which the individual flowers have no bracts, but the whole inflorescence is enclosed in a long bract called a spathe. This is well seen in the Cuckow-pint (*Arum maculatum*) (*fig.* 380). When a spadix branches, as in Palms (*fig.* 394), it is called *compound* or *branching*. The term spadix is also frequently applied to a succulent spike, whether enveloped in a spathe or not.

d. *The Locusta or Spikelet.*—This name is applied to the partial inflorescence of Grasses (*fig.* 382), and Cyperaceous plants. It is a

Fig. 394.

Fig. 394. Branched spadix of a Palm (*Chamærops*).

spike with a few flowers, and these destitute of a true calyx and corolla, their place being occupied by *paleæ*, and the whole inflorescence surrounded at the base by one or two empty bracts (*glumes*). These spikelets may be either arranged sessile on the primary axis or rachis (*fig.* 395) as in Wheat, the whole in-

Fig. 395.

Fig. 396.

Fig. 395. Inflorescence of Wheat (*Triticum*), consisting of numerous spikelets arranged on a common axis (*rachis*).—— *Fig.* 396. Branched inflorescence of the Oat (*Avena sativa*).

florescence of which may be therefore called a *compound spike;* or they may be placed on a more or less branched axis, as in the Oat, &c. (*fig.* 396).

e. *The Cone.*—This is a kind of spike, found especially in cone-bearing plants, as the Larch, Pine, Fir, &c. (*fig.* 397.) It is composed of female flowers, each of which has at its base a persistent woody scale or bract.

Fig. 397.

Fig. 397. Cone of Hemlock Spruce (*Abies canadensis*).

f. *The Strobilus or Strobile.*—This is a kind of spike with female flowers, each of

which has a membranous bract or scale at its base. It is seen in the Hop (*Humulus Lupulus*) (*fig.* 398).

Fig. 399.

Fig. 398.

Fig. 398. Strobile of the Hop (*Humulus Lupulus*). —— *Fig.* 399. Raceme of a species of Cherry (*Cerasus*).

All the kinds of indefinite inflorescence at present described owe their essential characters to the flowers being *sessile* upon an elongated axis. We now pass to describe others, in which the primary axis is more or less branched, and the flowers consequently situated upon stalks. The simplest of these is the Raceme.

g. *The Raceme.*—This name is applied to that form of inflorescence in which the primary axis is elongated, and bears flowers placed on pedicels of nearly equal length (*fig.* 399). It differs from the spike only, in the flowers being stalked instead of sessile. Examples occur in the Currant, Mignonette, Hyacinth, Laburnum, Barberry, Fumitory, &c.

h. *The Corymb.*—This is a kind of raceme in which the pedicels are of different lengths, viz. those at the base of the primary axis longer than those towards and at the apex, so that the whole form a level, or slightly convex top. It occurs in some species of Cerasus (*fig.* 400), the Hawthorn, &c. When the stalks or secondary axes of a corymb instead of bearing flowers immediately, divide and form tertiary or other axes, upon which they are placed, it is termed *compound* or *branching*, as in some species of Pyrus (*fig.* 401), &c. It sometimes happens that when the flowers are first developed they form a corymb, but as the primary axis elongates a raceme is produced. This may be seen in many Cruciferous Plants.

Fig. 400. *Fig.* 401.

Fig. 400. Simple corymb of a species of Cerasus. *a′*. Primary axis, bearing bracts *b b*, from the axils of which pedicels *a″ a″* arise. —— *Fig.* 401. Compound or branching corymb of the Wild Service tree (*Pyrus torminalis*). *a′*. Primary axis. *a″*, *a″*. Secondary axes. *a‴*, *a‴*. Tertiary axes. *b*, *b*, *b*. Bracts.

i. *The Panicle.*—This is a sort of compound raceme, that is to say, a raceme in which the secondary axes instead of producing flowers directly, branch, and form tertiary axes, &c., the ultimate subdivisions of which bear the flowers (*fig.* 402).

Fig. 402.

Fig. 402. Panicled inflorescence.

Examples of this occur in the *Yucca gloriosa*. in the general arrangement of the inflorescence of the Oat (*fig.* 396), &c.

k. *The Thyrsus or Thyrse.*—This is a kind of panicle in which the pedicels are generally very short, and the whole so arranged as to form a compact cluster (*fig.* 403). Examples may be found in the Horse-chestnut and Lilac.

Fig. 403.

Fig. 403. Thyrsus of Vine (*Vitis vinifera*).

The above kinds of indefinite inflorescence all possess an elongated primary axis. We now proceed to describe those kinds in which the primary axis is shortened or dilated in various ways.

2. *Kinds of Indefinite Inflorescence with a Shortened or Dilated Primary Axis.*—Of these we shall notice three varieties; the Capitulum or Anthodium, the Hypanthodium, and the Umbel.

a. *The Capitulum, Anthodium, or Head.*—This kind of inflorescence constitutes the Compound Flower of Linnæus. It is formed by a number of sessile flowers crowded together on a re-

Fig. 404.

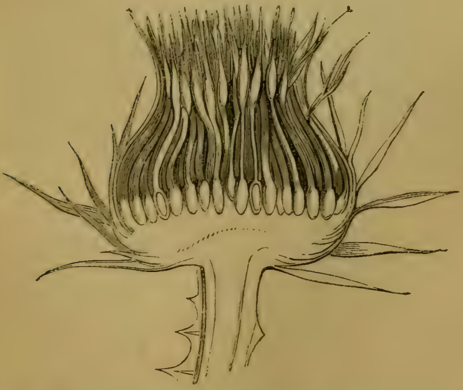


Fig. 404. Capitulum of Cotton Thistle (*Onopordum Acanthium*).

ceptacle, and the whole surrounded by an involucre. The receptacle as we have seen (see page 193) may be either flattened as in the Cotton Thistle (*fig.* 404); or slightly convex, as in the Dandelion; or conical, as in the Chamomile (*fig.* 381); or globular, as in the American Button Bush; or elliptical, &c., by which a variety of forms is given to the heads of flowers. This kind of indefinite inflorescence, as well as all others with shortened or dilated primary axes, also exhibit a centripetal order of expansion. This may be well seen in the capitulum of the Scabious (*fig.* 405), where the outer flowers, (or florets as they are commonly called from their smallness), are fully expanded, those within them less so, and those in the centre in an unopened condition. Here therefore the order of expansion is towards the centre—that is, centripetally.

b. *The Hypanthodium.*—This kind of inflorescence is but a slight modification of the last. It is formed by a receptacle which is usually of a fleshy nature becoming more or less incurved, and thus partially, as in the Dorstenia (*fig.* 384), or entirely, as in the Fig (*fig.* 383), enclosing the flowers which it bears upon its surface. The flowers in this kind of inflorescence are usually unisexual, and there is no involucre to them as in the true Capitulum.

Fig. 405

Fig. 406.

Fig. 405. Capitulum of Scabious (*Scabiosa*). The outermost florets may be observed to be more expanded than the inner.——*Fig.* 406. Simple umbel of a species of Allium.

c. *The Umbel.*—When the primary axis is shortened, and gives off from its apex a number of secondary axes or pedicels

of nearly equal length, each bearing a flower, and arranged like the ribs of an umbrella, an *umbel* is formed, as in the Primrose, Cowslip, &c. (*fig.* 406). When the secondary axes themselves divide, and form tertiary axes, which are also arranged in an umbellate manner, a *compound umbel* is produced (*fig.* 407). This is seen in the Carrot (*fig.* 375), the Fennel (*fig.* 407), the

Fig. 407.

Fig. 407. Compound umbel of Fennel (*Fœniculum*).

Fool's Parsley, the Hemlock, and other allied plants, which are hence called *umbelliferous*, and give the name to the natural order Umbelliferæ. In the compound umbel the primary umbel is called the *general umbel*, and the others formed by the divisions of this, *partial umbels* or *umbellules*. When the base of the general umbel is surrounded by a whorl of bracts, they constitute a *general involucre*, and if other bracts are arranged in a similar manner around the partial umbels, each forms an *involucel* or *partial involucre*. These have been alluded to previously when speaking of bracts.

On comparing the simple umbel with the capitulum, it will be seen that it bears the same relation to it, as the raceme does to the spike. The compound umbel again, may be considered to bear the same relation to the simple umbel, as the panicle does to the raceme. Or if we compare all the kinds of inflorescence now described, we perceive that the chief difference between them arises from the shortening or non-development of different axes, and their varying lengths. Thus, the capitulum is a spike with a shortened and enlarged axis, the umbel a raceme with a similar axis, and the raceme a stalked spike.

2. Definite, Determinate, or Terminal Inflorescence.—In this class of inflorescence the primary axis (as we have seen) is arrested in its growth at an early age by the development of a terminal flower-bud, and if the axis bears no other flowers this is called a *solitary terminal* flower, and is the simplest form of definite inflorescence. It may be seen in the stemless Gentian (*Gentiana acaulis*) (*fig.* 408), in the Wood

Fig. 408.

Fig. 409.

Fig. 408. Floral axis of a species of Gentian (*Gentiana acaulis*), terminated by a solitary flower, below which are two bracts. —— *Fig.* 409. A plant of a species of Ranunculus (*Ranunculus bulbosus*). *a'*, *a'*. Primary axis terminated by a fully expanded flower *f'*. *a''*. Secondary axis which is also terminated by a flower *f''*, not so fully developed as *f'*. *a'''*. Tertiary axis terminated by a flower-bud *f'''*.

Anemone (*Anemone nemorosa*), &c. When other flowers are produced on such an axis they must necessarily arise from axillary buds placed below the terminal flower-bud, and if these form secondary axes (*fig.* 409, *a''*) they will in like manner be arrested in their growth by a terminal flower-bud *f''*, and if other axes *a'''* are developed from the secondary, these also must be axillary, and will be arrested in a similar manner *f'''*, and may also form others of a like character, and so on. Hence this mode of inflorescence is *determinate*, *definite*, or *terminal*, in contradistinction to the former or indefinite inflorescence al-

ready described, where the primary axis elongates indefinitely unless stopped by some extraneous cause. Definite inflorescences are most common and regular in plants with opposite or whorled leaves, but they also occur in those which have alternate leaves, as for instance in the Buttercup (*Ranunculus*) (*fig.* 409), and the Columbine (*Aquilegia vulgaris*). In definite inflorescences we have a different order of unfolding in the flower-buds to those of the indefinite, because in them the terminal flower is the first developed and consequently the oldest (*fig.* 409 *f′*), and other buds are produced in succession from the apex to the base, if the axis be elongated (*fig.* 414), or if depressed or dilated, from the centre to the circumference. The uppermost flower-bud of the elongated axis, and the central one of the depressed or dilated axis will accordingly open first, and the lowermost of the former, and the most external of the latter, last. Such an order of expansion is called *centrifugal.* Hence while the indefinite kinds of inflorescence are characterised by a centripetal order of expansion, those of definite inflorescences are centrifugal.

Kinds of Definite Inflorescence.—The general name of *cyme* is applied to all such inflorescences, but a few of them are also distinguished by special names:—

a. *The true Cyme.*—This term is commonly applied by botanists to a definite inflorescence which is more or less branched, the whole being developed in a corymbose manner, and thus assuming a somewhat flattened head, as in the Laurustinus (*fig.* 410) Dogwood and Elder; or a rounded one, as in

Fig. 410.

Fig. 410. Cyme of Laurustinus (*Viburnum Tinus*).

the Hydrangea; or more or less spreading as in the Chickweed (*fig.* 411). In the more perfect and compact form of cyme, as found in the Laurustinus, Elder, &c., the flower-buds are all perfect before any of them open, and then the flowering takes place rapidly, commencing in the centre of the cyme, and then in the centre of each of its divisions, and thence proceeding in an outward direction; and as the central flower of each cluster corresponds to the apex of each branch, the expansion of the whole is centrifugal. By attention to this order of expansion such cymes may be always distinguished from indefinite kinds of inflorescence, such as the umbel, or corymb, to which otherwise they bear in many cases a great resemblance. In the Chickweed (*fig.* 411), and many other plants, the formation of the secondary and other axes a'' a''' a'''' goes on throughout the growing season, and in such cymes, which are usually of a more or less spreading nature the centrifugal or *cymose* (as it is also called) order of expansion may be well observed. The above cymes are also characterised as *dichotomous*, or *trichotomous*, according to the number of their branches, thus they are dichotomous, as in the common Centaury (*Erythræa Centaurium*) (*fig.* 412), when the primary axis a' is terminated by a flower f', at the base of which are two bracts, each of which developes in its axil secondary axes a'' a'', ending in single flowers, f'' f''; and at the base of each of these flowers there are also two other bracts, from which tertiary axes a''' a''' a''' are developed, also terminated by flowers f''' f''' f''' and so on, and as the division in this case always takes place into two branches, the cyme is said to be *dichotomous*. If

Fig. 411.

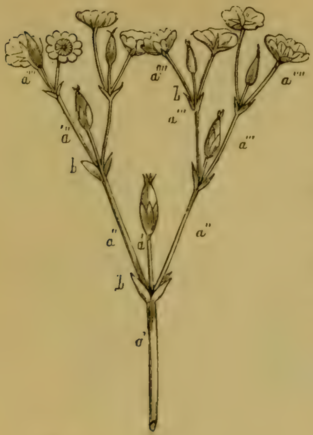


Fig. 411. Cyme of a species of Chickweed (*Cerastium*). a', a'. Primary axis terminated by a flower. a'', a''. Secondary axes, arising from the axils of opposite bracts *b*, and terminated also by flowers. a''', a''', a'''. Tertiary axes, arising from bracts *b*, and bearing other bracts *b*, from which other axes arise a'''', a'''', a''''.

Fig. 412.

Fig. 413.

Fig. 412. Cymose inflorescence of the Centaury (*Erythræa Centaurium*). a', a'', a''', a''''. Floral axes. f', f'', f''', f''''. Flowers terminating those axes respectively. —— *Fig.* 413. Spiked cyme of *Sedum*.

the division of the cyme takes place in threes, it is said to be *trichotomous.* Cymes are also frequently characterised as corymbose, or umbellate, according as they resemble the ordinary kinds of indefinite corymb, or umbel.

When a definite inflorescence does not assume a more or less corymbose form as in the true cyme just described, it is best characterised by terms derived from the kind of indefinite inflorescence to which it bears a resemblance. Thus when a cyme has sessile flowers, as in the Sedum (*fig.* 413), it is described as a *spiked*

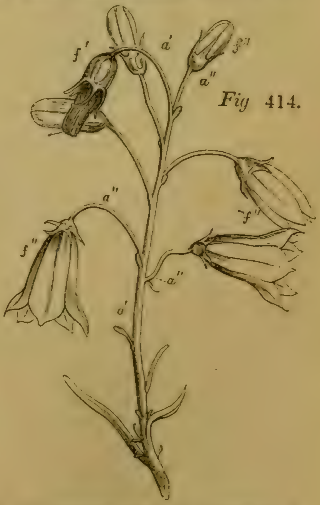


Fig 414.

Fig. 414. Racemose cyme of a *Campanula.* a', a'. Primary axis, terminated by a flower f', which is already withering. a'', a'', a''. Secondary axes, each ending in a flower, f'', f'', f''.

cyme; when it has its flowers on pedicels of nearly equal length, as in the Campanula (*fig.* 414), as a *racemose cyme;* or when it assumes the form of a panicle, as in the Privet (*fig.* 415), as a *panicled cyme.* These forms of cymes are readily distinguished from the true racemes, &c., by the terminal flowers opening first, and the others expanding in succession towards the base, or in a centrifugal manner; while in the true raceme the flowers open first at the base and last at the apex, or centripetally.

Fig. 415.

Fig. 416.

Fig. 415. Panicled cyme of the Privet (*Ligustrum vulgare*). *a'*. Primary axis. *a'' a''* Secondary axes. *a''' a'''*. Tertiary axes. c, c, the central flowers of the respective clusters, which are seen to be in a more expanded state than those surrounding them.——*Fig.* 416. Scorpioid cyme of the Forget-me-not (*Myosotis palustris*).

Besides the true cyme and its varieties mentioned above, other kinds have also received particular names, as the Helicoid Cyme, the Fascicle, the Glomerule, and the Verticillaster, which we must now briefly describe.

b. *Helicoid or Scorpioid Cyme.*—This is a kind of cyme in which the flowers are only developed on one side, and in which the upper extremity is more or less coiled up in a circinate or spiral manner, so as frequently to resemble a snail, or the tail of a scorpion, and hence the names of *helicoid* or *scorpioid* by which it is distinguished. It is also sometimes called a *circinate* or

gyrate cyme. These cymes are especially developed in the Boraginaceæ, as in the Forget-me-not (*Myosotis palustris*) (*fig.* 416), and in the Comfrey (*Symphytum*) (*fig.* 416*a*). In these plants

Fig. 416*a.*

Fig. 416*a.* Scorpioid cyme of Comfrey (*Symphytum officinale*).

the leaves are alternate ; but such a cyme may also occur in opposite-leaved plants, and the manner in which it is commonly believed to be formed in the two cases, is as follows :—Thus, in plants in which the leaves or bracts are opposite (*fig.* 417) it arises by the regular non-development of the axes on one side, while those on the other side are as regularly produced. This will be readily explained by a reference to the diagram (*fig.* 417). Here *a*, represents the flower which terminates the primary axis : at its base are two bracts, only one of which developes a secondary axis *b*, which is in like manner terminated by a flower, at the base of which are also two bracts, only one of which, (i. e. that on the same side with the first,) produces a tertiary axis *c*, also terminated by a flower with two bracts at its base, one of which gives origin to another axis *d*, placed in a similar manner, and so on. The place of the axis which is unde-

Fig. 417.

Fig. 417. Diagram to illustrate the formation of a scorpioid cyme in a plant with opposite bracts or leaves. *a*. Flower terminating the primary axis. *b*. Secondary axis. *c*. Tertiary axis. *d*. Quaternary axis. Each terminated by a flower.

veloped at each ramification is indicated by a dotted line. In consequence of this one-sided, (or as it is called *secund*) manner, in which the secondary branches are produced, the direction of the inflorescence is constantly drawn to one side at the formation of each axillary branch, and that in proportion to the size of the angle formed by it with the branch from which it springs, and thus when the angle is large, and many flowers are produced in succession, the upper extremity becomes completely coiled up in a circinate manner. In a plant with an alternate arrangement of its leaves or bracts, the helicoid cyme, arises from the primary axis (*fig.* 418, 1) being terminated by a flower, and giving off below it from the uppermost bract or leaf a secondary axis 2, which also terminates in a flower, and gives off in like manner, from the same side as the former a third axis 3, and so on, as seen by the figures. The place of the bracts is indicated by the dotted lines. Hence, such a cyme consists of a series of single-flowered axes (unifloral) arranged in the form of a raceme, to which kind of inflorescence it is by some botanists considered to belong. When the bracts are developed, however, there ought to be no difficulty in distinguishing it, as in the ordinary raceme the flowers always arise from the axil of the bracts, whereas in the helicoid cyme they are placed opposite to the bracts, or at all events out of the axil (*fig.* 418). In those cases, however, where the bracts are abortive, as in most of the Borage tribe, its discrimination from the true raceme is often difficult or even impossible, and its nature can only be ascertained by comparison with allied plants.

Fig. 418.

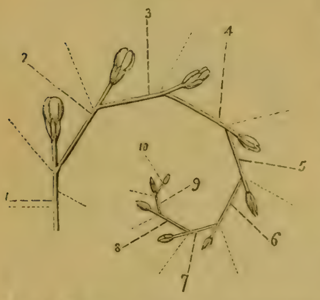


Fig. 418. Diagram to illustrate the formation of a scorpioid cyme in a plant with alternate bracts. The figures represent the respective axes, and the dotted lines the position of the bracts.

c. *The Fascicle or Contracted Cyme.*—This name is applied to a cyme which is rather crowded with flowers placed on short pedicels of nearly equal length, as in the Sweet-William and some other plants of the Pink tribe to which it belongs.

d. *The Glomerule.*—This is a cyme which consists of a number of sessile flowers, or those where the pedicels are very short, collected into a rounded head, or short spike. It is seen in species of Nettle

and in the Box (*fig.* 419), &c. It bears nearly the same relation to the true cyme, as the capitulum does to the umbel.

Fig. 419.

Fig. 419. Inflorescence of the Box (*Buxus sempervirens*).

e. *The Verticillaster.*—This kind of cyme is seen in the White Dead-nettle (*Lamium album*) (*fig.* 370) and in other plants of the Labiate tribe to which it belongs. In it the flowers appear at first sight to be arranged in a whorl round the stem, but upon examination it will be readily seen, that there are two clusters axillary to the opposite leaves, the central flowers of which open first, and hence the mode of expansion is centrifugal. To each of these clusters the name of *verticillaster* is applied.

We have now finished our description of the different kinds of regular inflorescence, and from what we have already stated, it may be readily understood that they may be situated either at the apex of the stem, or at the extremities of branches, or in the axils of leaves or bracts. Besides the above kinds, all of which are comprehended under the two classes of indefinite, or definite inflorescences, there is a third class, which consists in a combination of these, to which the term of *mixed inflorescence* has been accordingly given.

Fig. 420.

Fig. 420. Mixed inflorescence of a species of *Senecio*.

3. Mixed Inflorescence.—This kind of inflorescence is by no means uncommon. It is formed by the general inflorescence developing in one way, and the partial or individual inflorescences in another. Thus in plants of the natural order Compositæ (*fig.* 420), the terminal capitulum is the first to expand, and the capitula, as a whole, are therefore developed in a centrifugal manner; while the individual capitula open their small flowers or florets from the circumference to the centre, or

centripetally; hence, here the general inflorescence is *definite*, the partial inflorescence *indefinite*. In Labiate Plants we have a directly reverse arrangement (*fig.* 370), for here the individual clusters or verticillasters open their flowers centrifugally; but the general inflorescence is centripetal; hence the general inflorescence is *indefinite*, while the partial inflorescence is *definite*.

Section 2. Of the Parts of the Flower, and their Arrangement in the Flower-bud.

In common language, the idea of a flower is restricted to that portion in which its gay colours reside, but botanically, we understand by the flower, the union of all the organs which contribute to the formation of the seed. We have already stated that the parts of the flower are only leaves in a modified condition, or rather the *analogues* of those organs, or *homologous* formations adapted for special purposes; and that hence a flower-bud is to be considered as the analogue of a leaf-bud, and the flower itself of a branch, the internodes of which are but slightly developed, so that all its parts are placed in nearly the same plane. The detailed examination of this theoretical notion of a flower will be reserved till we have finished the description of its different parts or organs, when we shall be better able to understand it, as well as other matters connected with its symmetry, and the various modifications to which it is liable.

1. Parts of the Flower.—*A complete flower* consists of the essential organs of reproduction, enclosed in two particular envelopes which are destined to protect them. These essential organs are called Stamens (*fig.* 422, *ec*), and Pistil (*fig.* 422, *sti*). The floral envelopes are termed *Calyx* (*fig.* 421, *c*), and *Corolla* (*fig.* 421, *p*). The extremity of the peduncle or pedicel upon which the parts of the flower are placed, is called the *Thalamus* or *Receptacle* (*fig.* 422, *r*). The floral whorls are situated within each other in the following order, proceeding from without inwards:—1. Calyx, 2. Corolla, 3. Stamens, 4. Pistil.

The *Calyx* (*fig.* 421, *c*) is the outer envelope or covering of the flower. Its parts are called *Sepals*, and these are generally green, and of a less delicate texture than the parts of the corolla. They bear commonly a great resemblance to the true leaves.

The *Corolla* (*fig.* 421, *p*), is the whorl or whorls of leafy organs situated within the calyx, and forming the inner envelope of the flower. Its parts which are called *Petals*, are frequently decorated with the richest colours; by which character, and by their more delicate nature they may be usually known from those of the calyx.

The calyx and corolla are sometimes spoken of collectively under the name of *Perianth* or *Perigone* (*fig.* 424). This term is more particularly applied to Monocotyledonous Plants, where the floral envelopes generally resemble each other, and are usu-

Fig. 421.

Fig. 422.

Fig. 423.

Fig. 421. Flower of Wallflower (*Cheiranthus Cheiri*). *c.* Calyx composed of parts called sepals, the two lateral of which are prolonged at the base into a little sac, and hence are said to be gibbous. *p, p.* Petals of which there are four arranged in a cruciform manner, the whole forming the corolla. *e.* Summit of the stamens, which enclose the pistil. —— *Fig.* 422. Flower of Wallflower with the calyx and corolla removed, in order to show the essential organs of reproduction. *r.* Receptacle or thalamus. *gl.* Glands. *ec.* Stamen, of which there are six, four long and two short. *sti.* Stigma, the summit of the pistil. —— *Fig.* 423. One of the stamens of the Wallflower. *f.* Filament. *a.* Anther. *p.* Pollen.

ally all coloured or *petaloid* in their nature. The Tulip, the Iris, and the Crocus, may be taken as familiar examples.

The floral envelopes are called the *non-essential* organs of the flower, because their presence is not absolutely necessary for the production of the seed. Sometimes one floral envelope only is present, as in the Goosefoot (*Chenopodium*) (*fig.* 425), this

Fig. 424.

Fig. 425.

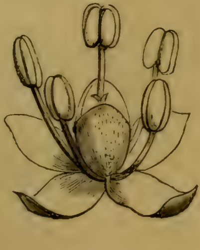


Fig. 424. Flower of a species of Squill (*Scilla italica*). The parts composing the floral envelopes here closely resemble each other, and form collectively a perianth. —— *Fig.* 425. Flower of Goosefoot (*Chenopodium*), with only one floral envelope.

is then properly considered as a calyx, whatever be its colour or other peculiarity, and the flower is said to be *Monochlamydeous.* Some botanists, however, use the term perianth in this case.

Fig. 426.

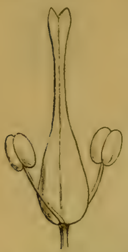


Fig. 426. Flower of the common Ash, in which the floral envelopes are altogether absent.

At other times, as in the Willow (*Salix*) and Ash (*fig.* 426), the floral envelopes are absent, when the flower is termed *naked* or *Achlamydeous.* When both floral envelopes are present, as in the complete flower above described (*fig.* 421), it is *Dichlamydeous.*

The *Stamens* constitute the whorl or whorls of organs situated on the inside of the corolla (*fig.* 422 *ec*). Each stamen consists essentially of a case or bag, called the *Anther* (*fig.* 423, *a*), which contains in its interior a powdery substance called the *Pollen* (*fig.* 423, *p*); this is discharged at certain periods through little slits or holes formed in the anther. These are the only essential parts of a stamen, but it generally possesses in addition, a little column or stalk, called the *Filament* (*fig.* 423, *f*), which then supports the anther on its summit. When the filament is absent, the anther is said to be *sessile.* The staminal system, taken collectively, is termed the *Andrœcium* from its constituting the male system of Flowering Plants.

The *Pistil* is the only remaining organ; it occupies the centre of the flower (*fig.* 422, *sti*), all the other organs being arranged around it when these are present. It consists of one or more modified leaves, called *Carpels,* which are either distinct from each other, as in the Columbine (*Aquilegia vulgaris*) (*fig.* 427), or combined into one body, as in the Poppy (*fig.* 428) and Tobacco (*Nicotiana Tabacum*) (*fig.* 568. 2). The carpels taken collectively constitute the *Gynœcium* or the female system of Flowering Plants. The pistil consists of a hollow inferior part, called the *Ovary* (*fig.* 429, *d*), which contains the rudimentary seeds called *Ovules o, o*; of a *Stigma,* or space of variable size, composed of lax cellular tissue without epidermis, which is either placed on the ovary, as in the Poppy (*fig.* 428, *sti*), or situated on a stalk-like portion prolonged from the ovary, called the *Style* (*fig.* 427, *sty*). The only essential parts of the pistil are consequently the Ovary and Stigma; the style being no more essential to it than the filament is to the stamen.

The stamens and pistil are called *essential organs* because their presence is necessary for the production of perfect seeds. It frequently happens, however, that either the stamens or pistil are absent in a flower, as in the Willow (*figs.* 392 and 393), in which case it is termed *unisexual,* and the flower is further

characterised as *staminal* or *male* (*fig.* 393), or *pistillate* or *female* (*fig.* 392), according as it possesses one or the other of those organs.

Fig. 427.

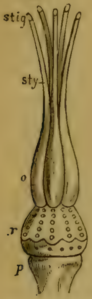


Fig. 428.

Fig. 429.

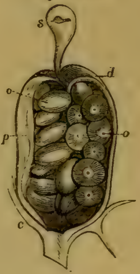


Fig. 427. Pistil of Columbine (*Aquilegia vulgaris*). *p.* Peduncle. *x.* Receptacle. *o.* Ovaries. *sty.* Styles. *sti.* Stigmas. —— *Fig.* 428. Pistil of Poppy (*Papaver*), with one stamen arising from below it. *o.* United ovaries. *sti.* Stigmas. —— *Fig.* 429. Vertical section of the pistil of the Pansy (*Viola tricolor*). *c.* Calyx. *d.* Ovary. *p.* Placenta. *o, o.* Ovules. *s.* Stigma on the summit of a short style.

2. Æstivation or Præfloration.—As the general arrangement of the leaves of the leaf-bud is termed *vernation* (the spring state), so the mode in which the different parts of the flower are arranged in the flower-bud is termed their *æstivation* (the summer state). The term *præfloration* is also sometimes used by botanists instead of æstivation. The terms used in describing the various modifications of æstivation are generally the same as those of vernation; but the former presents some peculiarities, which render it necessary for us briefly to refer to their different arrangements. The terms used in æstivation especially refer to the relative positions of the component parts of the calyx and corolla, because the stamens and pistil, from their peculiar forms, can give us no such arrangements of their parts as are exhibited by them.

In describing the modifications of æstivation, we have, as in the case of vernation, to include: 1st, The disposition of each of the component parts considered independently of the others; and 2nd, The relation of the several members of either of the floral envelopes taken as a whole in respect to each other. With regard to the disposition of each of the component parts considered independently of the others, the same terms are used as in those of vernation, with the addition of the *crumpled* or *corrugated* form, which only occurs in the parts of the floral envelopes. It may be seen in the petals of the Poppy and Rock-

rose (*Helianthemum*), and derives its name from the parts being irregularly contracted into wrinkled folds. The so-called distinctive forms to which the names of *induplicate* and *reduplicate* have been given, are merely modifications of the involute and revolute forms of vernation. They should be applied only (as will be presently shown), in describing certain forms of the general arrangement of the component parts of the respective floral envelopes.

With respect to the relation of the several members of either of the floral envelopes taken as a whole to each other, various forms occur, all of which may be arranged in two divisions; namely the *Circular*, and the *Imbricated* or *Spiral.* The former includes all those forms in which the component parts of the whorl are placed in a circle, and in nearly the same plane; and the latter where they are placed at slightly different levels in a more or less spiral manner, and overlap each other.

1. *Circular Æstivation.*—We distinguish three forms of this, i.e. the *valvate* or *valvular; induplicative* or *induplicate;* and the *reduplicative* or *reduplicate.* The valvate æstivation (*fig.* 430), may be seen in the calyx of the Lime, and in *Guazuma ulmifolia.* In this form the parts are flat or nearly so, and in contact by their margins throughout their whole length, without

Fig. 430.

Fig. 431.

Fig. 432.

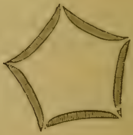


Fig. 430. Diagram to illustrate valvate æstivation.——*Fig.* 431. Diagram to illustrate induplicate æstivation.——*Fig.* 432. Diagram to illustrate reduplicate æstivation.

any overlapping. This form of æstivation may be generally distinguished, even when the flowers are expanded, by the margins of its component parts being slightly thickened, or at all events not thinner than the rest of the organ; whereas in all forms of imbricate or spiral æstivation, the overlapping borders are usually thinner, as may be well seen in the sepals of the Geranium. When the component sepals, or petals, instead of being flattened, are folded inwards at the points where they come in contact (*fig.* 431), the æstivation is *induplicative*, as in the petals of *Guazuma ulmifolia*, and in the calyx of some species of Clematis. When the margins are turned outwards under the same circumstances (*fig.* 432), the æstivation is *re-*

duplicative, as in the calyx of *Althæa rosea*, and some other Malvaceous Plants, and in the corolla of the Potato.

When the parts of a whorl are at the same height, or apparently so, as in the ordinary forms of circular æstivation, and one margin of each part is directed obliquely inwards, and is overlapped by the part adjacent on that side, while the other margin covers the corresponding margin of the adjoining part on the other side, so that the whole presents a more or less twisted appearance (*fig.* 433), the æstivation is *contorted* or *twisted*. This form may be considered as intermediate between the Circular and Imbricated forms of æstivation. It occurs very frequently in the corolla, but is very rare in the calyx. Examples may be seen in the corolla of *Althæa rosea*, and other Malvaceous Plants; in that of the common Flax (*Linum*), and generally in the order Linaceæ; in the Cyclamen; in the St. John's Wort (*Hypericum*); in the Periwinkle (*Vinca*), and in many other plants of the same order.

Fig. 433.

Fig. 434.

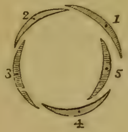


Fig. 435.

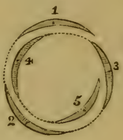


Fig. 436.

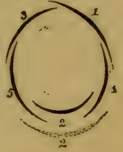


Fig. 433. Diagram to illustrate contorted or twisted æstivation.—*Fig.* 434. Diagram to illustrate imbricate æstivation. The figures 1, 2, 3, 4, 5, show that the successive parts are arranged in a spiral manner.—*Fig.* 435 Diagram to illustrate quincuncial æstivation. 1 and 2 are external, 4 and 5 internal, and 3 is partly external and partly internal.—*Fig.* 436. Diagram to illustrate cochlear æstivation. The part marked 2 in the preceding diagram is here wholly internal instead of external as in the quincuncial arrangement. The dotted line marked 2, indicates its normal position in the imbricate form of æstivation.

2. *Imbricated, Imbricative, or Spiral Æstivation.*—We shall describe five forms of this class of æstivation, i.e. the *imbricate*, *convolute* or *enveloping*, *quincuncial*, *cochlear*, and *vexillary*. The true *imbricate* æstivation, as seen for instance in the calyx of *Camellia japonica* (*fig.* 434), is formed by the parts being placed at different levels, and overlapping each other more or less by their margins like the tiles on a house, the whole forming a spiral arrangement. It is a very common form of æstivation. When the parts instead of merely overlapping, completely envelop each other, as in the calyx of *Magnolia grandiflora*, and in the corolla of *Camellia japonica*, the æstivation is termed *convolute* by some botanists; but this term is now more frequently applied to the contorted form of æstivation, when the parts overlap to a considerable degree as in the Wallflower. When

the parts of a floral whorl are five in number, and these imbricated in such a manner that there are two parts placed on the outside, two inside, and the fifth overlapping one of the internal by one margin, while it is itself overlapped on its other margin by one of the external parts, the æstivation is said to be *quincuncial* (*fig.* 435). Familiar examples of this form are afforded by the corolla of the Rose, and the calyx of the Bindweed (*Calystegia sepium*). In this form of æstivation the spiral arrangement of the parts is well seen, and is indicated in the diagram (*fig.* 435) by a dotted line. The spiral cycle thus formed, which is the normal one in *pentamerous* or *quinary* flowers (those with the parts in fives), and which occurs in the majority of Dicotyledonous plants, corresponds to the $\frac{2}{5}$ or *pentastichous* or five-ranked arrangement of leaves. When in a quincuncial arrangement the second part of the cycle becomes wholly internal, instead of being external as is ordinarily the case, the regularity of the quincunx is interrupted, and a form of æstivation occurs, to which the name *cochlear* has been given (*fig.* 436). A familiar example is afforded by the Frogsmouth (*Antirrhinum majus*) and other allied plants. Another modification of imbricate æstivation occurs in the flower-buds of the Pea and other plants allied to it (*fig.* 463), where the superior petal or that placed next the axis, called the *vexillum*, which is generally the largest, is folded over the others which are arranged face to face (*fig.* 437). This form of æstivation is commonly termed *vexillary*.

Fig. 437.

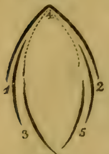


Fig. 437. Diagram to illustrate vexillary æstivation. 1 and 2 form the alæ or wings, 3 and 5 the carina or keel, 4 the vexillum.

It frequently happens that the calyx and corolla exhibit different forms of æstivation. Thus, in *Guazuma ulmifolia* the calyx is *valvate*, and the corolla *induplicative*. In Malvaceous plants the calyx is *valvate*, or *reduplicative*, and the corolla *contorted*. In these examples the different forms of æstivation, as exhibited by the two floral envelopes, may be considered to belong to the same class of æstivation, i.e. the *circular*; but instances also frequently occur where the forms in the calyx and corolla are different, and belong to both classes. Thus, in the Bindweed (*Calystegia*), and other Convolvulaceæ, the calyx is *imbricated*, and the corolla *contorted*. A similar arrangement occurs in the Corn Cockle (*Lychnis Githago*), in the St. John's Wort (*Hypericum*), in the Geranium, and many other plants.

The forms of æstivation above described are always constant in the same individual, and frequently throughout entire genera, and even natural orders, hence they are of great importance in systematic botany. For a similar reason they are also of much value in structural botany, by the assistance they commonly

afford in enabling us to ascertain the relative succession and position of the parts of the flower on the axis. The term *anthesis* is sometimes used to indicate the period at which the flower-bud opens.

Besides the definite and constant relations which the parts of the flower have to each other in the flower-bud, they also have a determinate and constant relation in the same plant to the axis upon which they are placed. In describing these positions we use the terms *anterior* or *inferior*, *superior* or *posterior*, and *lateral*. Thus, we call that organ *posterior* or *superior*, which is turned towards the axis, and that next the bract from the axil of which it arises, *inferior* or *anterior*. When there are four organs in a whorl, one will be *superior*, one *inferior*, and two *lateral*, as in the calyx of Cruciferous Plants (*fig.* 421). If there are five we have two arrangements. Thus, in the calyx of the Pea tribe of plants (*Leguminosæ*) two sepals are *superior*, two *lateral*, and one *inferior;* while in the corolla, in consequence of the law of alternation in the parts of the flower to be hereafter described, one petal is *superior*, two *inferior*, and two *lateral* (*fig.* 463). In plants of the Rose tribe (*Rosaceæ*),we have a precisely reverse position exhibited by the two outer floral whorls ; thus, here we have two sepals *inferior*, two *lateral*, and one *superior;* while in the corolla there are two petals *superior*, two *lateral*, and one *inferior* (*fig.* 462). From these relations of position being constant in the plants of Rosaceæ and Leguminosæ, we have here a constant character by which those orders may be distinguished.

The same definite relation with respect to the axis also holds good in many cases in the staminal and pistilline whorls, by which important distinctive characters are frequently obtained, as will be seen afterwards when treating of Systematic Botany.

Section 3.—The Floral Envelopes.

1. THE CALYX.

We have already stated that the calyx is the outermost envelope of the flower, and that it is composed of one or more leafy organs called *sepals*. These sepals are usually green like true leaves, by which character, as well as by their position, and more delicate texture, they may in most cases be distinguished from the petals. There are numerous instances, however, in which there is a gradual transition from the sepals to the petals, (especially when there is more than one whorl of these organs,) so that it is difficult or almost impossible, to say where the calyx ends and the corolla begins. The White Water-Lily (*Nymphæa alba*) (*fig.* 438), affords a familiar and good illustration of this. In some plants again, the green colour disappears, and the calyx becomes coloured with the same tints as the

Fig. 438.

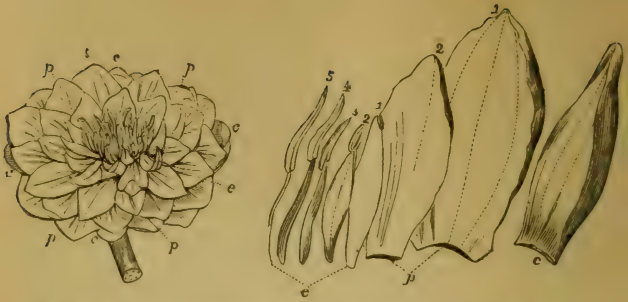


Fig. 438. Flower of the White Water-Lily (*Nymphæa alba*) reduced in size. After Jussieu. *c*, *c*, *c*, *c*. The four sepals. *p*, *p*, *p*, *p*. Petals. *e*. Stamens. The parts on the right show the gradual transition from the calyx *c* to the petals *p*, and from those organs again to the stamens *e*. The stamens from 1 to 5 are gradually more distinctive.

corolla, or of some other. In such cases it is said to be *petaloid*, and the chief distinctive character between it and the corolla is then afforded by its position on the outside of the latter organ. The Fuchsia, Indian Cress, Columbine, Larkspur, and Monkshood, may be mentioned as affording us examples of a petaloid calyx among Dicotyledonous Plants. In the Monocotyledonous Plants generally, as in the Lily, Iris, Tulip, Crocus, &c. (*fig.* 424), as we have mentioned, the two floral envelopes are usually coloured, and in other respects closely resembling each other, so that we then use the collective name of *perianth* to indicate the two whorls taken together. When there is but one whorl of floral envelopes, as in the Goosefoot (*Chenopodium*) (*fig.* 425), and in Birthwort (*Aristolochia*), it is customary with some botanists to call that whorl a calyx, whatever be its colour or other peculiarity. It is so termed in this volume. Other botanists, however, frequently term it a perianth under such circumstances, as we have already stated. (See p. 216.)

In their general structure, venation, &c., the sepals resemble true leaves, and are covered like them with epidermis, and this is frequently furnished on the lower and outer surface with stomata, and also occasionally with hairs, glands, and other appendages. From their duration being usually however more transitory than that of true leaves, the veins which form their skeleton chiefly consist of true spiral vessels, which are arranged like those of the leaves in the two classes of plants — that is reticulated in Dicotyledons, and parallel in Monocotyledons.

The sepals also exhibit various characters as regards their outline, apex, &c., although by no means so liable to variations

in such particulars as the true leaves. The terms used in defining those modifications are applied in the same sense as in these organs. Sepals are almost without exception destitute of a stalk, or sessile upon the axis. They are also generally entire at their margins, although exceptions to this character occasionally occur: thus, in the Pæony and in the Rose (*fig.* 439, *cf*), the sepals are divided at their margins; in many species of Dock (*Rumex*) they are toothed (*fig.* 440, *ci*); and in the *Chamælaucium plumosum* the calyx consists of five sepals, each of which is divided into five deep lobes. In their direction, the sepals are either *erect* or upwards; *connivent* or turned inwards; or spreading outwards, when they are *divergent* or *patulous*; or when their apices are turned downwards, *reflexed*.

Fig. 439.

Fig. 440.

Fig. 439. Vertical section of the flower of the Rose. *r, r.* Concave receptacle, upon which are placed several carpels, *o, o,* each of which is furnished with a style and stigma, *s.* *e, e.* Stamens. *ct.* Tube of the calyx. *cf, cf.* Free portions of the calyx divided at their margins.——*Fig.* 440. Calyx of *Rumex uncatus*, after Jussieu. *ce.* Outer divisions of the calyx, which are entire. *ci.* Inner divisions with hooked teeth at their margins. *g.* Swelling on one of the inner divisions.

The calyx may either consist of a number of separate parts or sepals, as in the Poppy, Buttercup, Wallflower, Strawberry, (*fig.* 441); or these parts may be more or less united into one body (*figs.* 443—445), as in the Fuchsia, Melon, Tobacco, &c. In the former case, the calyx is termed *polysepalous*, *dialysepalous*, or *polyphyllous*, the term *phylla* being sometimes used instead of sepal. When the parts of the calyx are united, it is called *monosepalous* or *monophyllous*; but these are incorrect terms, as they indicate literally one sepal, or one leaf, and hence many botanists use instead, the term *gamosepalous* or *gamophyllous* calyx, which is more correct, as these terms simply imply that the sepals or leaves are united.

1. Polysepalous or Polyphyllous Calyx.—A polysepalous calyx may consist of two or more parts, the number of which being indicated by the prefix of Greek numerals; as *disepalous* or *diphyllous* for a calyx composed of two distinct sepals, *tri-*

sepalous or *triphyllous* for one with three, *tetrasepalous* or *tetraphyllous* if it have four, *pentasepalous* or *pentaphyllous* if five, *hexasepalous* or *hexaphyllous* if six, *heptasepalous* or *heptaphyllous* if seven, and so on.

A polysepalous calyx is called *regular*, if it consist of sepals of equal size and like form arranged in a symmetrical manner, as in the Buttercup (*Ranunculus*) and Strawberry (*fig.* 441); it is *irregular* when these conditions are not complied with, as in the Monkshood (*Aconitum*) (*fig.* 442).

Fig. 441.

Fig. 442.

Fig. 441. Flower of Strawberry (*Fragaria*) with a regular polysepalous calyx surrounded by a whorl of leafy organs, to which the names of epicalyx and involucre have been applied. —— *Fig.* 442. Flower of Monkshood (*Aconitum Napellus*) with an irregular polysepalous calyx. The upper sepal is helmet-shaped or galeate.

2. Monosepalous, Monophyllous, or Gamosepalous Calyx.—When the sepals are united so as to form a monosepalous calyx, various terms are used to indicate the degree of adhesion. Thus, the union may only take place near the base,

Fig. 443.

Fig. 444.

Fig. 445.

Fig. 443. Partite calyx of the Pimpernel (*Anagallis*). —— *Fig.* 444. Cleft or fissured calyx of the Centaury (*Erythræa*). —— *Fig.* 445. Dentate or toothed calyx of Campion (*Lychnis*).

as in the Pimpernel (*Anagallis*) (*fig.* 443), when the calyx is said to be *partite;* or it may take place to about the middle, as in the Centaury (*Erythræa*) (*fig.* 444), when it is *cleft* or *fissured;* or the sepals may be united almost to the top, as in the Lychnis (*fig.* 445), when it is *toothed;* or if the union is quite complete, as in the Chrysanthemum (*fig.* 450), and some Correas, it is said to be *entire.* The number of partitions, fissures, or teeth, is indicated by the same prefixes, as those previously referred to as being used in describing analogous divisions in the blade of a leaf; thus the above calyx where the divisions are five, would be described as *five-parted* or *quinquepartite, five-cleft* or *quinquefid, five-toothed* or *quinquedentate*, according to the depth of the incisions. In like manner the terms tripartite, trifid, or tridentate, would indicate that a calyx was three-parted, three-cleft, or three-toothed, and so on. The number of divisions in the majority of cases corresponds to the number of component sepals in the calyx, although exceptions to this rule sometimes occur, as for instance in those cases where the divisions are themselves divided into others; a little care in the examination will, however, generally enable the observer to recognise the primary from the secondary divisions. When a monosepalous calyx is entire, the number of sepals can then only be ascertained by the venation, as the principal veins from which the others diverge generally correspond to the midribs of the component sepals. In a monosepalous calyx in which the union exists to some extent, the part where the sepals are united is called the *tube*, the free portion, the *limb*, and the orifice of the tube, the *throat* or *faux* (*fig.* 446).

If the union between the sepals is unequal, or the parts are of different sizes, or of irregular form, the calyx is said to be *irregular* (*fig.* 447); if, on the contrary, the parts are alike in form, of the same size, and united so as to form a symmetrical body, it is *regular* (*fig.* 445). Some forms of the irregular and regular calyx have received special names. Thus in the Dead-nettle (*Lamium*) (*fig.* 447), &c., the irregular calyx is said to be *bilabiate* or *two-lipped*, because the five sepals of which it is composed are united in such a manner as to form two lips. Of the regular forms of the monosepalous calyx, a number are distinguished under the names of *tubular*, bell-shaped or *campanulate*, *urceolate* or pitcher-

Fig. 446.

Fig. 447.

Fig. 446. Urceolate calyx of Henbane (*Hyoscyamus*).——*Fig.* 447. Bilabiate calyx of the Dead-nettle (*Lamium*).

shaped (*fig.* 446), *conical, globose,* &c. The application of these will be shown when speaking of the corolla, in which similar forms occur, and in which they are usually more evident.

The tube of a monosepalous calyx or perianth sometimes adheres more or less to the ovary, as in the Iris (*fig.* 629), Gooseberry, Currant, Myrtle (*fig.* 448), in all the plants of the order Compositæ, and in those allied to it (*figs.* 449, 450, and 451). When this takes place, the calyx is said to be *adherent* or *superior*, because it appears to arise from the summit of the ovary; the pistil in such a case is said to be *inferior.* When the calyx is free, or quite distinct from the sides of the ovary, as in the Pimpernel (*fig.* 443), Wallflower, Poppy, Buttercup, &c., it is *free* or *non-adherent*, or *inferior;* and the ovary is accordingly *superior.*

Fig. 448.

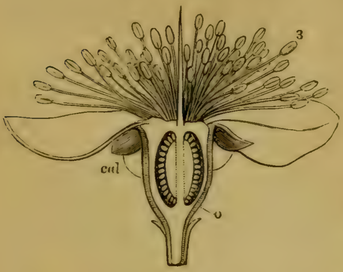


Fig. 448. Vertical section of the flower of the Myrtle (*Myrtus communis*). *cal.* Tube of the calyx adherent to the ovary *o.* 3. Stamens.

Fig. 449. *Fig.* 450. *Fig.* 451.

Fig. 449. Calyx of the Madder (*Rubia*), adherent to the ovary, with its limb reduced to a mere rim. —— *Fig.* 450. One of the tubular florets of the Ox-eye (*Chrysanthemum*). The calyx is completely united to the ovary and presents no appearance of a limb. —— *Fig.* 451. One of the florets of the Sunflower (*Helianthus*). The limb of the adherent calyx is membranous.

When the calyx or perianth is thus adherent to the ovary, the limb becomes variously modified: thus in the Iris, Crocus, and Orchids, it is *petaloid;* in the Quince, *foliaceous* (*fig.* 459); in the Sunflower (*Helianthus*) (*fig.* 451), and Chamomile, it is *membranous;* in the Madder (*Rubia*) (*fig.* 449), it exists only in the form of a circular rim; while in the Chrysanthemum it is altogether absent (*fig.* 450). In the two latter cases the calyx is commonly described as *obsolete.* In many plants of the

order Compositæ and the allied orders Dipsaceæ and Valerianaceæ, the limb of the calyx is only developed in the form of a circle, or tuft of bristles or hairs, to which the name of *pappus* is given, and the calyx under such circumstances is said to be *pappose*. The pappus is described as *feathery* or *plumose*, and *simple* or *pilose*; thus it is *feathery*, as in the Valerian (*fig*. 452),

Fig. 452. *Fig*. 453.

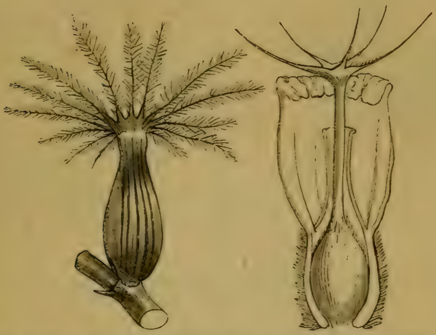


Fig. 452. Fruit of Valerian surmounted by a feathery sessile pappus.—— *Fig*. 453. Fruit of Scabious surmounted by a stalked pilose pappus.

and Salsafy, when each of its divisions is covered on the sides by little hair-like projections arranged like the barbs of a feather; it is *pilose*, when the divisions have no visible projections from their sides, as in the Dandelion and Scabious (*fig*. 453). The pappus is also described as *sessile* when it arises immediately from the tube of the adherent calyx, and thus apparently from the top of the ovary, as in the Valerian (*fig*. 452); and *stalked* or stipitate, if it is raised above the ovary on a stalk, as in the Dandelion and Scabious (*fig*. 453).

The calyx, whether monosepalous or polysepalous, is subject to various irregularities besides those already alluded to, arising from the expansion of one or more of its sepals into appendages of various kinds; some of the more important of these may be briefly alluded to. Thus in the Monkshood (*Aconitum*) (*fig*. 442), the superior sepal is prolonged upwards into a sort of hood or helmet-shaped process, in which case it is said to be *hooded*, *helmet-shaped*, or *galeate*. In the Wallflower (*Cheiranthus*) (*fig*. 421), and other plants of the Cruciferæ, the two lateral sepals are expanded on one side at the base into little sacs, when they are termed *gibbous* or *saccate*. The latter term is only applied by some botanists when the sac-like form of the

expansions is very evident. If the calyx has one or more tubular prolongations downwards, it is said to be *calcarate* or *spurred*. Only one spur may be present, as in the Indian Cress (*Tropæolum*) (*fig.* 454), where the spur is formed by three sepals,

Fig. 454.

Fig. 455.

Fig. 454. Flower of the Indian Cress *c.* Spurred calyx.—— *Fig.* 455. Flower of Columbine (*Aquilegia vulgaris*) with all the sepals spurred.

or in the Larkspur, where it is formed by one; or each of the sepals may be spurred, as in the Columbine (*Aquilegia*) (*fig.* 455). In the Pelargonium, the spur instead of being free from the pedicel, as in the above instances, is united to it.

Fig. 456.

Fig. 456. Calyx of Hibiscus surrounded by an epi-calyx or involucre.

On the outside of the calyx of some flowers, as in those of many Malvaceous plants (*fig.* 456), and also in those of the Pink (*fig.* 460) and Rose tribes (*fig.* 441), there is placed a whorl of leaf-like organs which are considered by some botanists as an outer calyx, to which the names of *calyculus* and *epi-calyx* have been given, but these are evidently of the same nature as the *involucre* already noticed (see page 189). The external covering of each of the flowers and fruits (*fig.* 453) of the Scabious, furnish us another example of this calyciform involucre.

The duration of the calyx varies in different flowers. Thus it is *caducous* or *fugacious*, when it falls off as the flower expands, as in the Poppy (*fig.* 457). In the *Eschscholtzia* the caducous calyx separates from the hollow thalamus to which it is articu-

Fig. 457. *Fig.* 458. *Fig.* 459.

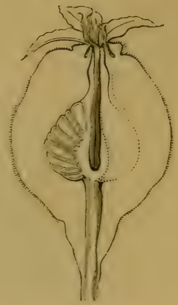


Fig. 457. Flower of Poppy, showing a caducous calyx.—— *Fig.* 458. Accrescent calyx of the Winter Cherry (*Physalis Alkekengi*).—— *Fig.* 459. Vertical section of the fruit of the Quince (*Cydonia vulgaris*), showing the tube of the calyx adherent to the ovary, and its limb foliaceous.

lated, in the form of a funnel, or the extinguisher of a candle. A somewhat similar separation of the calyx occurs in the Eucalyptus, except that here the part which is left behind after the separation of the upper portion, evidently belongs to the calyx, instead of the thalamus as in the former instance. Such a calyx is said to be *calyptrate* or *operculate.* When the calyx falls off about the same time as the corolla, as in the Crowfoot or Buttercup, it is called *deciduous.* In other cases it remains after the flowering is over, as in the Henbane (*fig.* 446), Mallow, &c. When the calyx is adherent or superior it is necessarily persistent, and forms a part of the fruit, as in the Quince (*fig.* 459), Apple, Pear, Gooseberry, Melon, Cucumber, &c. When it is persistent and assumes a shrivelled or withered appearance, as in the Campanulas, it is *marcescent;* if it is persistent, and continues to grow after the flowering, so as to form a bladdery expansion round the fruit, as in the Winter Cherry, and other species of Physalis (*fig.* 458), it is termed *accrescent.*

2. THE COROLLA.

The corolla is the inner envelope of the flower. It consists of one or more whorls of leafy organs, called *petals.* In a complete flower (*fig.* 421, *p*) it is situated between the calyx and stamens, and is generally to be distinguished from the former, as we have already seen, by its coloured nature and more delicate structure. When there is but one whorl of floral envelopes, as we have also before noticed, this is to be considered as the calyx, and the flower is then termed

apetaloid. The corolla is usually the most showy and conspicuous part of the blossom, and what in common language is termed the flower. In some rare cases, however, it is green like the calyx, as in certain Cobœas and Asclepiadaceous plants. The corolla is also, in the majority of flowers which possess odoriferous properties, the seat of those odours. Sometimes, as we have seen, there is a gradual transition from the sepals to the petals, as in the White Water-Lily (*Nymphæa*) (*fig.* 438); in the same plant there is also a similar transition from the petals to the stamens.

In structure the petals resemble sepals and leaves, being composed of parenchyma, supported by veins which are chiefly formed of true spiral vessels. These veins are generally reticulated. The whole petal is invested by a layer of epidermis, which is usually destitute of stomata, but these organs may be sometimes found on the lower surface. The corolla is generally smooth, although hairs occasionally occur, as in the Bombax; when they exist they are usually coloured, as in the Buckbean, and on the inner whorl of the perianth of the Iris, which corresponds in position to the corolla. Petals are frequently narrowed below into a stalk-like portion, which is analogous to the petiole of a leaf, as in the Wallflower (*Cheiranthus*) (*fig.* 421, *p*) and Pinks (*Dianthus*) (*figs.* 460 and 461); the narrowed portion is then termed the *unguis* or *claw* (*fig.* 461, *o*), the expanded portion the limb (*fig.* 461, *l*), and the petal is said to be *unguiculate* or *clawed.* In this particular petals must be considered to resemble leaves more than the sepals do, as the latter organs are almost without exception *sessile*, or without claws.

Fig. 460.

Fig. 461.

Fig. 460. The flower of a species of Pink (*Dianthus*). *b.* Bracts. *c.* Calyx. *p.* Petals. *e.* Stamens. —— *Fig.* 461. One of the petals of the same flower. *o.* Claw or unguis. *l.* Limb, which is fringed at the margin.

The outline of petals, like those of leaves, is subject to great variation. Thus, they may be *linear*, *oblong*, *lanceolate*, *elliptic*, *orbicular*, *ovate*, *cordate*, &c. The application of these terms having been already fully explained when speaking of leaves, need not be further alluded to. The condition

of their margins also; the mode in which those are divided; and the terminations of petals are also indicated by the same terms as those previously described under similar heads in our chapter on leaves. Thus the petals may be *dentate*, or *serrated; cleft*, *partite*, *sected; acute*, *emarginate*, &c. The petals are not however liable to any further division than that of the original one; thus, although sometimes *pinnatifid*, or *pinnatipartite*, &c., they are never *bipinnatifid*, or *bipinnatipartite*. One term is occasionally used in describing the condition of the borders which has not been alluded to when speaking of leaves. Thus they are said to be *fimbriated* or *fringed*, as in some species of Dianthus (*fig.* 460), when they present long thread-like processes.

In form also, the petals may be either flat, as is usually the case, or they may be *concave*, *tubular*, or *boat-shaped*, &c. The terms used sufficiently explain their meaning. A few anomalous forms of petals will be explained hereafter. In texture they are commonly soft and delicate, but they sometimes differ widely from this, and become thick and fleshy, as in the Stapelia; or dry and membranous, as in Heaths; or stiff and hard, as in Xylopia.

In describing their direction, we use the terms *erect*, *connivent*, *divergent*, *patulous*, or *reflexed*, in the same sense as already described when speaking of the sepals (p. 223).

The petals like the sepals may be either distinct, or more or less united into one body. In the former case, the corolla is said to be *polypetalous* or *dialypetalous* (*fig.* 460); in the latter, *monopetalous* or *gamopetalous* (*fig.* 464). We shall describe the different kinds of corolla under these two heads.

1. Polypetalous or Dialypetalous Corolla.—The number of petals which enter into the composition of the corolla is indicated, as in the case of the polysepalous calyx, by the prefix of the Greek numerals. Thus a corolla of two petals, is said to be *dipetalous*, of three, *tripetalous*, of four, *tetrapetalous*, of five, *pentapetalous*, of six, *hexapetalous*, of seven, *heptapetalous*, of eight, *octopetalous*, and so on.

When the petals are all of the same size and form, and arranged in a symmetrical manner, the corolla is termed *regular*, as in Cruciferous flowers (*fig.* 421); when the petals vary in these particulars, as in the Pea and allied plants (*fig.* 463), it is said to be *irregular*. Some forms of these have received special names, which we will now proceed to describe under the two divisions of *regular* and *irregular* polypetalous corollas.

A. *Regular Polypetalous Corollas.*—Of these we may mention three forms, viz., the *cruciform* or *cruciate*; the *caryophyllaceous*; and the *rosaceous*.

1. *Cruciform* or *Cruciate.*—This corolla gives the name to the natural order *Cruciferæ* or *Mustard Family*. It consists of four petals, usually with claws, as in the Wallflower (*fig.* 421),

and Stock, but sometimes without claws, as in the Celandine, and the whole arranged in the form of a cross.

2. *Caryophyllaceous.*—This consists of five petals, with long claws enclosed in the tube of the calyx, and with their limbs commonly placed at right angles to the claws, as in the Lychnis, Single Pink, Carnation, Catchfly, &c. (*fig.* 460.)

3. *Rosaceous* —This is composed of five petals, without, or with very short claws, and spreading in a regular manner, as in the Strawberry (*fig.* 441). Single Rose, &c. (*fig.* 462.)

Fig. 462

Fig. 463.

Fig. 462. Flower of the Rose. *b.* Bract. *ct.* Tube of the calyx. *cf, cf, cf, cf, cf.* Divisions of the calyx. *p, p, p, p, p.* Petals.——*Fig.* 463. The Flower of the Sweet Pea (*Lathyrus odoratus*). *c.* Calyx. *v.* Vexillum. *a.* Alæ or wings. *car.* Carina or keel.

B. *Irregular Polypetalous Corollas.*—There are many anomalous forms of irregular polypetalous corollas, as in the Monkshood (*Aconitum*) (*fig.* 442.), Heartsease, &c., to which no particular names are applied. There is one form, however, of such corollas, which is of importance, namely,

The *Papilionaceous.*—This derives its name from the fancied resemblance which it bears to a butterfly. It is composed of five petals, one of which is superior and larger than the others, and is termed the *vexillum* or *standard* (*fig.* 463, *v*); two inferior, which are usually more or less united, and form a somewhat boat-shaped cavity (*fig.* 463, *car*), called the *keel* or *carina ;* and two lateral (*fig.* 463, *a*) called *wings* or *alæ.*

2. Monopetalous or Gamopetalous Corollas.—When the petals unite so as to form a monopetalous corolla, various terms are used as in the case of the monosepalous calyx to indicate the degree of adhesion ; thus the corolla may be *partite, cleft, toothed,* or *entire*, the terms being employed in the same sense as with the calyx. The part also where the union has taken place, is called the *tube;* the free portion, the *limb ;* and the orifice of the tube, the *throat* or *faux* (*fig.* 464).

The monopetalous corolla like that of the calyx, is *regular* when the parts are of the same size and form, and united so as to form a symmetrical body (*figs.* 464—469); or if these conditions are not complied with, it is *irregular* (*figs.* 470—476).

A. *Regular Monopetalous Corollas.*—Among these we may describe the following:—

1. *Tubular*, where the form is nearly cylindrical throughout, as in the central florets of many Compositæ, as Ragwort (*Senecio*), Chrysanthemum (*fig.* 450), and Milfoil (*Achillæa*), &c. (*fig.* 464).

2. *Campanulate* or *bell-shaped*, when rounded at the base, and gradually enlarging to the summit, so as to resemble a bell in shape, as in the Harebell (*fig.* 465).

3. *Infundibuliform* or *funnel-shaped*, where the shape is that of an inverted cone, like a funnel, as in Convolvulus, and Tobacco (*Nicotiana*) (*fig.* 466).

Fig. 464.

Fig. 465.

Fig. 466.

Fig. 464. Flower of *Spigelia marylandica*. c. Calyx. *t*. Tubular corolla. *l*. Limb of the corolla. *s*. Summit of the style and stigmas.——*Fig.* 465. Flower of the Harebell (*Campanula rotundifolia*), showing a bell-shaped corolla.——*Fig.* 466. Flower of Tobacco (*Nicotiana Tabacum*), with infundibuliform corolla.

4. *Hypocrateriform* or *salver-shaped* (*fig.* 467, *p*), when the tube is long and narrow, and the limb placed at right angles to it, as in Phlox, Auricula, and Primrose.

5. *Rotate* or *wheel-shaped*, when the tube is short, and the

limb at right angles to it, as in Forget-me-not (*Myosotis*) (*fig.* 468), and Bittersweet (*Solanum Dulcamara*).

6. *Urceolate* or *pitcher-shaped*, when swollen in the middle, and contracted at both the base and apex, as in the Purple Heath (*Erica*) (*fig.* 469) and Bilberry (*Vaccinium Myrtillus*).

Fig. 467.

Fig. 468.

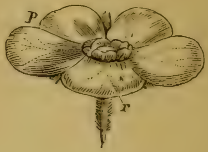


Fig. 469.

Fig. 467. Flower of a species of *Primula*. *c*. Calyx, within which is seen a salver-shaped corolla *p*. *t*. Tube of the corolla. *l*. Limb.—— *Fig.* 468. Flower of the Forget-me-not (*Myosotis palustris*). *p*. Rotate corolla. *r*. Scales projecting from its limb.—— *Fig.* 469. Flower of a species of Heath (*Erica*). *c*. Calyx, within which is an urceolate corolla, *t*, *l*.

B. *Irregular Monopetalous Corollas.*—Of these we shall describe the following :—

Fig. 470.

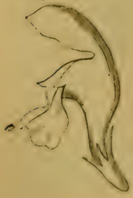


Fig. 471.

Fig. 470. Ringent corolla of Dead-nettle (*Lamium*).—— *Fig.* 471. Back view of the flower of a species of *Teucrium*, showing the bifid upper lip of the corolla.

1. *Labiate* or *lipped.*—When the parts of a corolla are so united as to divide the limb into two portions which are placed superiorly and inferiorly, and the upper portion overhanging the lower, each without closing the orifice of the tube, so that the whole resembles in some degree the lips and mouth of an animal (*figs.* 470—473), the corolla is termed *labiate*, *bilabiate*, or *lipped*. The upper lip is usually composed of two petals, which are either completely united, as in the White Dead-nettle (*Lamium album*) (*fig.* 470), or more or less divided, as in the Rosemary (*Rosmarinus*) (*fig.* 472), Teucrium (*fig.* 471),

&c.; and the lower of three, which are also, either entire, as in the Rosemary (*fig.* 472), or bifid, as in Lamium (*fig.* 470), or trifid, as in the Galeobdolon (*fig.* 473). When a labiate form of corolla has the upper lip much arched, as in the White Dead-nettle (*Lamium*) (*fig.* 470), it is frequently termed *ringent.* The labiate form of corolla gives the name to the natural order Labiatæ, in the plants belonging to which it is of almost universal occurrence. It is found also in certain plants belonging to some other orders.

Fig. 472.

Fig. 473.

Fig. 472. Flower of Rosemary (*Rosmarinus*). —— *Fig.* 473. Front view of the labiate corolla of *Galeobdolon.*

2. *Personate or masked.*—This form of corolla resembles the labiate in being divided into two lips, but it is distinguished by the lower lip being approximated to the upper, so as to close the orifice of the tube or throat. This closing of the throat is caused by a projection of the lower lip called the *palate.* It occurs in the Snapdragon (*fig.* 474), Toadflax (*Linaria*) (*fig.* 475), &c. In the Calceolaria the two lips become hollowed out in the form of a slipper, hence such a corolla, which is but a slight modification of the above, is sometimes termed calceolate.

Fig. 474.

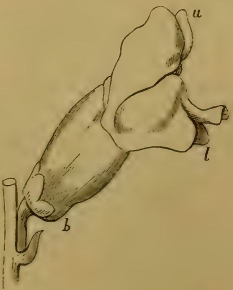


Fig. 475.

Fig. 474. Personate corolla of Snapdragon (*Antirrhinum*). *l.* Lower lip. *u.* Upper lip. *b.* Gibbous base. —— *Fig.* 475. Personate corolla of the Toadflax (*Linaria*) spurred at its base.

3. *Ligulate* or *strap-shaped.*—This is a tubular corolla which is partly split open on one side, so as to become strap-shaped (*figs.* 476 and 477). This occurs commonly in the florets of the Compositæ, either in the whole of those constituting the capitulum, as in the Dandelion (*Leontodon*), or only in a part, as in the florets of the ray of Chrysanthemum (*fig.* 477). The

Fig. 476.

Fig. 477.

Fig. 478.

Fig. 476. Ligulate corolla of a Composite flower.—*Fig.* 477. Ligulate corolla of Ox-eye (*Chrysanthemum*).—*Fig.* 478. Digitaliform or glove-shaped corolla of Fox-glove (*Digitalis purpurea*).

apex of a ligulate corolla has frequently five teeth indicating the component petals (*fig.* 476).

Fig. 479.

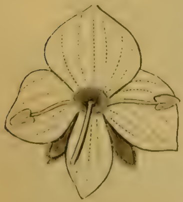


Fig. 479. Irregular rotate corolla of Speedwell (*Veronica*).

Besides the above described forms of regular and irregular monopetalous corollas, others also occur, some of which are but slight modifications of them, and arise from irregularities in certain parts in the progress of their development. Thus in the Fox-glove (*Digitalis*) (*fig.* 478), the general appearance of the corolla is somewhat bell-shaped, but it is longer than that form, and slightly irregular, and has been supposed to resemble the finger of a glove; it has therefore received the name of *digitaliform* or *glove-shaped.* In the Speedwell (*Veronica*) (*fig.* 479), the corolla is nearly rotate, but the divisions

are of unequal size. In the Red Valerian (*Centranthus*), the corolla is an irregular salver-shaped (*fig* 481), and some other examples might be alluded to, but we must now proceed to describe some of the anomalous forms and appendages of petals.

Anomalous Forms and Appendages of Petals.—The corolla like the calyx, whether polypetalous or monopetalous, is subject to various irregularities, arising from the expansion or growing outwards of one or more of their petals into processes of different kinds. Some of these we now proceed to describe. Thus in the Snapdragon (*Antirrhinum*) (*fig.* 474, *b*), and Valerian (*Valeriana*) (*fig.* 480), the lower part of the tube of the corolla becomes dilated on one side, and forms a little bag or sac, it is then termed *saccate* or *gibbous*, this term being used in the same sense as previously described when speaking of the calyx. At

Fig. 480.

Fig. 481.

Fig. 482.

Fig. 480. Flower of Valerian (*Valeriana*). *c.* Calyx, adherent to the ovary. *l.* Limb of the calyx rolled inwards. The corolla has a projection towards its base, and is said to be gibbous.——*Fig.* 481. Flower of Red Valerian (*Centranthus*). The corolla is irregularly salver-shaped and spurred.——*Fig.* 482. A portion of the flower of the Monkshood (*Aconitum*), with numerous stamens below, and two stalked horn-shaped petals above.

other times, one or more of the petals, or the tube of a monopetalous corolla becomes prolonged downwards, and forms a *spur*, in which case the corolla or individual petals are described as *spurred* or *calcarate*. Examples of spurred petals or corollas may be seen in the Heartsease, Columbine, Toadflax (*Linaria*) (*fig.* 475), Red Valerian (*Centranthus*) (*fig.* 481), &c. The Yellow Toadflax, which usually only produces one spur, in rare instances is found with five. Such a variety was termed by Linnæus *Peloria*, a name which is now applied by botanists to all flowers

which exhibit this curious departure from their ordinary growth. In the Monkshood (*Aconitum*) (*fig.* 482) the two petals which are situated under the helmet-shaped sepals already noticed (*fig.* 442), are each shaped somewhat like a curved horn placed on a long channelled stalk.

The corolla is usually composed of but one whorl of petals, and it is then termed *simple*, but in some flowers there are two or more whorls, as in the White Water-Lily (*fig.* 438), in which case it is *multiple*. When the corolla is composed of but one whorl, its parts in a regular arrangement alternate with the sepals, although cases occur in which they are opposite to them. The reason of this will be explained hereafter, under the head of the General Morphology and Symmetry of the Flower.

On the inner surface of the petals of many flowers, we may frequently observe appendages of different kinds in the form of scales or hair-like processes of various natures. These are commonly situated at the junction of the claw and limb, or at the base of the petals, as in Mignonette (*Reseda*) (*fig.* 484), Ranunculus (*fig.* 483), Lychnis (*fig.* 486), Parnassia (*fig.* 485), &c. Similar

Fig. 483.

Fig. 484.

Fig. 485.

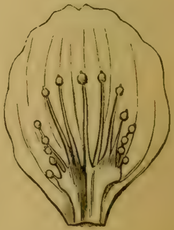


Fig. 483. Petal of Crowfoot with a nectariferous scale at its base. —— _Fig._ 484. One of the petals of Mignonette (_Reseda_). —— _Fig._ 485. A petal of the Grass of Parnassus (_Parnassia palustris_) bearing a fringed scale.

scales may be also frequently noticed in monopetalous corollas near the throat (*fig.* 468), as in many Boragineous plants, for instance the Comfrey, Borage, Forget-me-not (*fig.* 468, *r*), also in the Dodder, &c.

Sometimes these scales become more or less coherent and form a cup-shaped process, as in Narcissus (*fig.* 487), to this the term *corona* is commonly applied, and the corolla is then said to be crowned. By many botanists, however, this term is applied, whenever the scales or appendages are arranged in the form of a ring on the inside of the corolla, whether united or not. The beautiful fringes on the corolla of the Passion-flower are of a similar nature. The origin of these scales is by no means clearly ascertained; by some botanists, they are supposed to be derived from the petals, by others, to be abortive stamens;

Fig. 486. *Fig.* 487.

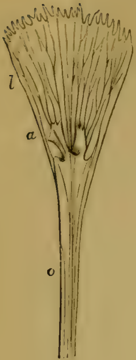


Fig. 486. A petal of a species of Lychnis. *o.* Claw. *l.* Limb. *a.* Scaly appendage.——*Fig.* 487. Flower of Daffodil (*Narcissus Pseudo-narcissus*). The cup or bell-shaped part towards the centre is termed a corona.

their origin probably varies in different flowers. We shall return to this subject hereafter under the head of General Morphology and Symmetry of the Flower. By the old botanists many of these appendages were described under the head of nectaries, although but few of them possess the power of secreting the honey-like matter or nectar from which they derived their names; they were therefore improperly so termed. The nature of the so-called *nectaries* has been already described under the head of Glands.

The duration of the corolla varies like that of the calyx, but it is almost always more fugitive than that organ. It is *caducous* if it falls as the flower opens, as in the Grape-vine; commonly it is *deciduous*, or falls off soon after the opening of the flower. In rare instances it is *persistent*, in which case it usually becomes dry and shrivelled, as in Heaths and Campanulas, when it is said to be *marcescent.*

3. DEVELOPMENT OF THE FLORAL ENVELOPES.

The manner in which the floral envelopes are developed may be shortly summed up as follows:—

1. They are subject to the same laws of development as the leaves of a bud, and hence make their first appearance as little

cellular processes which grow by additions to their bases or points of attachment to the axis.

2. The calyx is always developed before the corolla.

3. When a calyx is polysepalous, or a corolla polypetalous, the component sepals or petals make their first appearance in the form of little distinct papillæ or tumours, the number of which correspond to the parts of the future calyx or corolla.

4. When a calyx is monosepalous, or a corolla monopetalous, the first appearance of these organs is in the form of a little ring, which ultimately becomes the tube of the calyx or corolla as the case may be. When these present lobes or teeth, as they more commonly do, they arise as little projections on the top of the ring, the number of which correspond to the future divisions of the calyx or corolla.

5. All irregular calyces or corollas are regular at their first formation, the cellular papillæ from which they arise being all equal in size; hence all irregularity is produced by unequal subsequent growth.

Section 4.—The Essential Organs of Reproduction.

Fig 488.

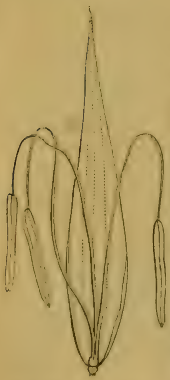


Fig. 488. Unisexual staminate flower of a species of Carex. The filaments are long and capillary, and the anthers pendulous and innate.

The essential organs of reproduction are the stamens and pistil, which together constitute the two inner whorls of the flower. They are so called because the presence of both is necessary for the production of perfect seed. The staminal whorl is termed the *Andrœcium*, and the pistillate the *Gynœcium.*

Flowers which possess both these organs are called *hermaphrodite* or *bisexual* (*fig.* 422). When only one is present, they are *unisexual* or *diclinous*, as in the Carex (*fig.* (488), Willow, &c. (*figs.* 392 and 393); the flower is then described as staminate or staminiferous (*figs.* 393 and 488) when it contains only stamens, and pistillate or pistilliferous when it has only a pistil (*fig.* 392). When a flower possesses neither stamens nor pistil, as is sometimes the case with the outer florets of the capitula of the Compositæ, it is said to be *neuter*. When the flowers are unisexual, both staminiferous and pistilliferous flowers may be borne upon the same plant, as in the Hazel, Oak, Cuckow Pint (*fig.* 380), and Carex, in which case the plant is stated to be *monœcious*; or upon different plants of the same species as in Willow (*figs.* 392 and 393), Hemp, and

Mercurialis, when it is *diœcious*. In some cases, as in many Palms and Pellitory (*Parietaria*), both staminiferous, pistilliferous, and hermaphrodite flowers, are situated upon the same individual, in which case the plant is called *polygamous*.

Like the calyx and the corolla, the stamens and pistil are considered as homologous with leaves, but they generally present much less resemblance to those organs than the floral envelopes. Their true nature is shown however, by their occasional conversion into leaves, and by other circumstances which will be described hereafter when treating of the General Morphology of the Flower. They make their first appearance upon the upper part of the axis or thalamus as small cellular processes, in the same manner as the floral envelopes.

1. THE STAMENS OR ANDRŒCIUM.

The stamens constitute the whorl or whorls of organs situated between the corolla on the outside and the pistil on the inner (*figs.* 421 and 422), and form collectively the andrœcium or male organs of the flower. Each stamen consists generally of a thread-like portion or stalk, called the *filament* (*fig.* 423, *f*), which is analogous to the petiole of the leaf, and of a little bag or case, *a*, which is the representative of the blade, called the *anther*, which contains a powdery matter termed the pollen, *p*. The only essential part of the stamen is the anther containing the pollen, and when this is absent, as the stamen cannot then perform its special functions, it is said to be *abortive* or *sterile*. When the filament is absent, which is but rarely the case, as in the Arum (*fig.* 489), the anther is described as *sessile*.

Fig. 489.

Fig. 489. Stamen of the Arum, consisting simply of an anther sessile upon the thalamus.

1. THE FILAMENT.—In its structure the filament consists, 1st, of a central bundle of spiral vessels which is usually unbranched and terminates at the connective of the anther; 2nd, of cellular tissue which surrounds the central bundle of spiral vessels, and which is itself covered by a thin epidermal layer. The epidermis occasionally presents stomata and hairs. These hairs are sometimes coloured, as in the Spiderwort (*Tradescantia*), and in the Dark Mullein (*Verbascum nigrum*). The structure of the filament is thus seen to be strictly analogous to that of the petiole of a leaf, which presents a similar disposition of its component parts.

The filament varies in form, length, colour, and other particulars; a few of its more important modifications in these respects will be now alluded to.

Form.—As its name implies, the filament is usually found in the form of a little thread-like or cylindrical prolongation which

generally tapers in an almost imperceptible manner from the base to the apex, it is then described as *filiform*, as in the Rose; or when it is very slender, as in most Grasses and Sedges, it is *capillary* (*figs.* 488 and 490). In the latter case, the filament instead of supporting the anther in the erect position as it usually does, becomes bent, and the anther is pendulous. At other times the filament becomes enlarged, or flattened in various ways. Thus in some cases, it is dilated gradually from below upwards like a club, when it is *clavate* or *club-shaped*, as in *Thalictrum*; or it is slightly enlarged at the base, and tapers upwards to a point like an awl, as in the flowering rush (*Butomus umbellatus*); in other cases it is flattened at the base (*fig.* 491), but there is no marked tapering, the rest of the fila-

Fig. 490.

Fig. 491.

Fig. 492.

Fig. 490. A locusta of Wheat (*Triticum*) consisting of several flowers, the stamens of which have very long capillary filaments, and versatile pendulous anthers. The anthers are bifurcated at each extremity, and resemble somewhat the letter x in form. —— *Fig.* 491. Three of the stamens of the *Tamarix gallica*, with their filaments flattened at the base and united with one another. —— *Fig.* 492. Pistil of *Campanula*, with a solitary stamen arising from the summit of the ovary. The filament is flattened.

ment assuming its ordinary rounded form, as in *Tamarix gallica* (*fig* 491); or the whole of the filament is flattened, and then it frequently assumes the appearance of a petal, when it is described as *petaloid*, as in the Water-Lily (*Nymphæa*) (*figs.* 438, *e*, and 509), and in the Canna and allied plants.

Sometimes the filament is *toothed*, as in the Allium (*fig.* 493), or *forked*, as in Crambe (*fig.* 494) or furnished with various appendages, as in the Borage (*fig.* 495), and Zygophyllum, in which case it is said to be *appendiculate*. These appendages are evidently of the same nature as the scales, &c., previously described as occurring on the corolla.

Length, Colour, and Direction.—The length of the filament varies much. Thus in the Borage and plants generally of the

Fig. 493.

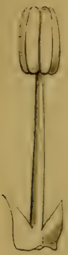


Fig. 494.

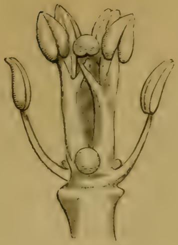


Fig. 495.

Fig. 493. Dilated toothed filament of a species of Allium.——*Fig.* 494. Pistil and andrœcium of Crambe. The longer filaments are forked.——*Fig.* 495. A stamen of the Borage (*Borago officinalis*). *f.* Filament. *a.* Curved appendage to the filament. *l.* Anther.

order Boragineæ to which it belongs, the filaments are very short (*fig.* 496); in the Primrose and Primulaceæ generally, a similar condition occurs. In the Fuchsia, Lily, Grasses (*fig.* 490), &c., they are generally very long.

In colour they are usually white, but at other times they assume vivid tints like the corolla; thus in the Spiderwort (*Tradescantia*), they are blue, in various species of Ranunculus, Œnothera, &c., yellow, in some Poppies, black, in Fuchsia, &c., red.

Fig. 496.

Fig. 497.

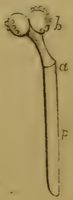


Fig. 496. Corolla of *Myosotis* laid open. There are five stamens attached to the corolla and included within its tube, with very short filaments.——*Fig.* 497. Male flower of *Euphorbia*, consisting of a solitary stamen *b*, without any floral envelopes surrounding it, hence it is said to be naked or achlamydeous. *a.* Articulation, indicating the point of union of the true filament and peduncle *p*.

In direction, the filaments and consequently the stamens are either *erect*, *incurved*, *recurved*, *pendulous*, &c.; these terms being

used in their ordinary acceptation. When the filaments are all turned towards one side of the flower, as in the Horse Chestnut. Fraxinella, and Amaryllis, they are said to be *declinate*. Generally speaking the direction is nearly continuous from one end of the filament to the other, but in some cases this is departed from in a remarkable manner, and the upper part of the filament forms an angle more or less obtuse with the lower, the filament is then termed *geniculate*, as in the *Mahernia*. This appearance commonly arises from the presence of an articulation at the point where the angle is produced, as in *Euphorbia* (*fig.* 497). In such a case, or whenever an articulation exists on the apparent filament, this is not to be considered as a true filament, but to consist in reality of a flower-stalk supporting a single stamen. The flower here therefore, is reduced to a stalk bearing a single stamen, all the parts except it being abortive. This is proved by the occasional production in some allied plants of one or more whorls of the floral envelopes at the point where the joint is situated. In the Pellitory the filament assumes a spiral direction.

The filament usually falls off from the thalamus after the influence of the pollen has been communicated to the pistil,—that is after the process of fertilization has been completed. In rare cases, as in the Campanula, it is persistent, and remains attached to the ovary in a withered condition.

2. The Anther.—*Its Development, and Structure.*—Like the leaf, the anther is first developed as a little cellular protuberance, the apex being formed first as is also the case with that organ, and the whole completed like the lamina of the leaf before the formation of the filament or stalk. At first the cellular protuberance is solid (*fig.* 498), and exhibits no appearance of cavities apart from those common to all cellular structures; at an early age, however, we may observe the formation of an epidermal layer *ce*, surrounding the mass of cellular substance *ci* in its interior. As growth advances the cellular mass becomes altered at certain points, usually at four (two of which are placed in each half of the anther,) (*figs.* 499 and 500), by the formation of as many masses *cm* of large cells, which undergo a special development to be afterwards described, to produce the pollen; each of these masses is surrounded by a special layer which ultimately forms the inner lining of the anther, *cl*. As these aggregations of cells continue to develop they press upon the

Fig. 498.

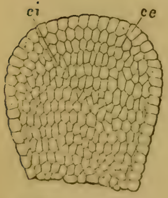


Fig. 498. Vertical section of a young anther of the Melon (*Cucumis Melo*). *ce*. Cells at the circumference forming an epidermal layer. *ci*. Internal cells. From Maout.

Fig. 499.

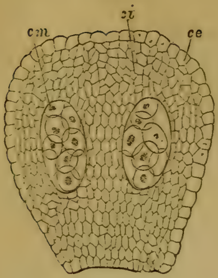


Fig. 500.

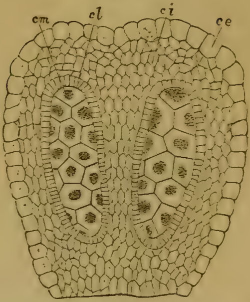


Fig. 499. Vertical section of a cell of a young anther of the Melon, showing its gradual growth and separation into regions. *ce.* Epidermal cells. *ci.* Internal cells in progress of absorption by the development of the masses of cells *cm*, in their interior.——*Fig.* 500. Vertical section of a cell of a young anther of the Melon in a more advanced state. *ce.* Epidermal layer constituting the exothecium or outer covering of the anther. *ci.* The internal parenchymatous cells still farther absorbed. The masses of cells *cm* are now distinctly seen to contain pollen; they are hence called parent or mother cells. These cells are surrounded by a special covering of cells *cl*, and this layer ultimately forms the endothecium. From Maout.

surrounding parenchyma *ci* to a greater or less extent, and thus cause its corresponding absorption. When the absorption is complete and the two pollen-forming masses of cells themselves unite, we have an anther formed of two large pollen cavities or cells. If these masses do not unite, a portion of the original cellular mass remains as a sort of partition between them, and the anther consists of four cells.

Fig. 501.

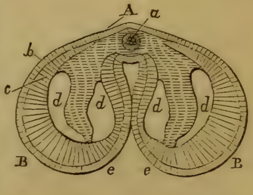


Fig. 501. Transverse section of an unopened anther of *Neottia picta.* From Schleiden. A. Connective. B, B. The two lobes of the anther. *a.* Vascular bundle of the connective. *b.* Epidermal layer or exothecium. *c.* Layer of fibrous cells forming the endothecium. *d, d, d, d.* The four loculi or cells of the anther. Each lobe is seen to be divided into two loculi by a septum or partition. *e, e.* The sutures or points where dehiscence ultimately takes place.

The different parts of which the anther is composed may be best seen by making a transverse section (*fig.* 501). Thus here we observe two parallel *lobes*, B, B, separated by a portion, A, *a*, called the *connective*, to which the filament is attached. Each lobe is divided into two cavities, *d, d, d, d,* by a septum which passes from the connective to the walls of the anther. The cavities thus formed in the lobes are called cells, *loculi*, or

thecæ. A young anther always possesses, as we have seen, four loculi, and this is considered the normal state. When a

Fig. 502.

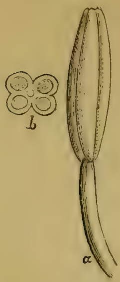


Fig. 503.

Fig. 504.

Fig. 502. Quadrilocular anther of the Flowering Rush (*Butomus umbellatus*). *a.* Filament bearing an entire anther. *b.* Section of the anther with its four loculi.——*Fig.* 503. Andrœcium of Milkwort (*Polygala*), with one-celled anthers dehiscing at their apex.——*Fig.* 504. One of the stamens of the Lady's Mantle (*Alchemilla*). The anther is unilocular or one-celled, and dehisces transversely.

Fig. 505.

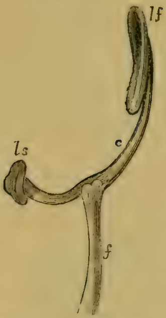


Fig. 505. Stamen of the Sage. *f.* Filament. *c.* Connective bearing at one end a loculus *lf*, containing pollen, when it is said to be fertile; and at the other end a loculus *ls*, without pollen, in which case it is sterile.

fully developed anther exhibits a similar structure, as in the Flowering Rush (*Butomus umbellatus*), it is four-celled, *quadrilocular*, or *tetrathecal* (*fig.* 502); or when as is more commonly the case, the partitions separating the two loculi of each anther-lobe become absorbed, it is two-celled, *bilocular*, or *dithecal* (*fig.* 490). In rare cases, the anther is *unilocular* or one-celled, as in the Mallow, Polygala (*fig.* 503), Alchemilla (*fig.* 504): this arises, either from the abortion of one lobe of the anther, or by the destruction of the partition wall of the two lobes as well as of the septa between the loculi of each lobe. In some plants again, as in many species of Salvia, the connective becomes elongated into a kind of stalk, each end of which bears an anther lobe (*fig.* 505), in which case there appears to be two *monothecal* or *unilocular* anthers. When this occurs one lobe only *lf* contains pollen, the other *ls* is sterile.

That surface of the anther to which the connective is attached is called the *back* (*fig.* 501, A, *a*), and the opposite surface is the *face*. The latter always presents a more or less grooved appearance (*fig.* 501), indicating the point of junction of the two lobes. Each lobe again commonly presents also a more or less evident fur-

row (*fig.* 501, *e*), indicating the point at which the anther will open to discharge the pollen, which is termed the *suture*. By these furrows the face of the anther may be generally distinguished from the back, which is commonly smooth and has moreover the filament attached to it. The face is generally turned towards the pistil or centre of the flower, as in the Water-Lily and the Vine (*fig.* 506), in which case the anther is called *introrse;* in some instances, as in the Iris, and Meadow Saffron (*fig.* 507), it is directed towards the petals or circumference, when it is said to be *extrorse.*

Fig. 506.

Fig. 507.

Fig. 506. The Essential Organs of Reproduction of the Vine (*Vitis vinifera*). *a.* Anther. *c.* Furrow in its face which is turned towards the pistil. *b.* Suture or line of dehiscence. The anther is introrse. —— *Fig.* 507. The Perianth and stamens of the Meadow Saffron (*Colchicum autumnale*) showing its anthers turned towards the floral envelopes, and hence termed extrorse.

In structure each lobe of the mature anther consists of two layers (*fig.* 501, *b*, *c*); an outer *b*, which resembles that kind of modified epidermis termed epithelium, and is called the *exothecium*, upon which stomata are frequently found; and an inner *c*, which corresponds to the covering of the masses of pollen-forming cells (*fig.* 500, *cl*), and is termed the *endothecium.* This inner lining consists of fibro-cellular tissue, formed of either spiral, annular, or more commonly reticulated cells, arranged in one or more rows (*fig.* 508 *cf*). The membrane forming the walls of these cells usually becomes obliterated

Fig. 508.

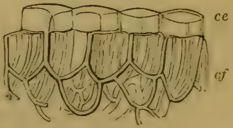


Fig. 508. Horizontal section of a portion of the wall of an anther of the *Cobæa scandens* at the time of dehiscence. It is composed of an external epidermal layer *ce*, forming the exothecium, and an internal layer of fibrous cells *cf*, forming the endothecium.

as the anther approaches maturity, the fibrous threads or bands alone remaining in the form of spires, rings, or branched filaments. This layer gradually diminishes in thickness as we approach the suture, and at that line it is altogether wanting. At the suture the exothecium is also commonly thinner than upon the other parts of the lobe. The connective has a structure which in its essential characters usually resembles the filament, i.e. it is composed of a bundle of spiral vessels enclosed in a mass of parenchyma covered by epidermis. Frequently the connective consists of parenchyma only.

We have already shown that the floral envelopes are homologous with leaves, representing them as they do in all their essential characters. We have now to examine the stamen with the view of ascertaining whether its parts also have any resemblance to those of the leaf. We have no difficulty in recognising the filament as the homologue of the petiole, both from its form, position, and structure, in all of which particulars it is essentially the same. The connective of the anther again, is clearly analogous to the midrib of the leaf, and hence we readily see that the two lobes of the anther correspond to the two halves of the lamina folded upon themselves; in fact if we take a leaf and fold it in the above manner, and then make a transverse section, it will present a great resemblance to the section of the anther already described (*fig.* 501). We may therefore conclude, that the anther corresponds to the lamina of the leaf, the connective to the midrib, the outer surface to the epidermis of its lower side, and the septa to the epidermis of the two halves of the upper surface of the lamina united and considerably thickened. The pollen also corresponds to the general parenchyma situated between the epidermis of the upper and lower surfaces of the leaf.

Attachment of the Filament to the Anther.—The mode in which the anther is attached to the filament varies in different plants, but it is always constant in the same individual, and hence the characters afforded by such differences are important in practical botany. There are three modes of attachment which are characterised by special names. 1st. The anther is said to be *adnate*, when its back is attached throughout its whole length to the filament, or its continuation called the connective, as in the Buttercup (*Ranunculus*), Magnolia (*fig.* 513), Water-Lily (*fig.* 509), and Barberry; 2nd, it is *innate*, when the filament is only attached to its base and firmly adherent, as in Carex (*fig.* 488), and Tulip (*fig.* 510); 3rd, it is *versatile*, when the filament is only attached by a point to the back of the connective, so that the anther swings upon it, as in Grasses generally (*fig.* 490), in the Lily, in the Evening Primrose, and in the Meadow Saffron.

Fig. 509.

Fig. 510.

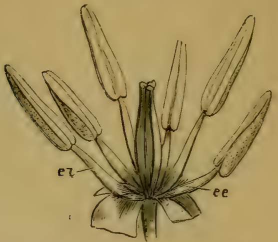


Fig. 509. A portion of the flower of the White Water-Lily (*Nymphæa alba*) consisting of a pistil invested by a large fleshy disk prolonged from the thalamus below it. The pistil is surrounded by some stamens with petaloid filaments and adnate anthers, and by two petals. —— *Fig.* 510. Pistil and stamens of the Tulip. The stamens *ei* and *ee* have innate anthers.

Connective.—The relations of the anther to the filament, as well as the lobes to each other, are much influenced by the appearance and size of the connective. Thus in all adnate anthers the connective is large, and the lobes more or less parallel to each other generally throughout their whole length (*fig.* 513). In other cases the connective is very small, or altogether wanting, as in the Euphorbia (*fig.* 511), so that the lobes of the anther

Fig. 511.

Fig. 512.

Fig. 513.

Fig. 514.

Fig. 515.

Fig. 511. A male naked flower of a species of Euphorbia, showing the two lobes of the anther, and the almost total absence of the connective. —— *Fig.* 512. A stamen of the Lime (*Tilia*) showing the large connective separating the lobes of the anther. —— *Fig.* 513. An inside view of a stamen of *Magnolia glauca*, showing the adnate anther and prolonged connective. —— *Fig.* 514. Two stamens of the Heartsease (*Viola tricolor*). The connective of one of them is prolonged downwards in the form of a spur. —— *Fig.* 515. Sagittate anther lobes of the Oleander (*Nerium Oleander*). The connective is prolonged upwards in the form of a long feathery process.

are then immediately in contact at their bases. In the Lime the connective completely separates the two lobes of the anther (*fig.* 512). In the Sage (*fig.* 505) and other species of Salvia, it forms a long stalk-like body placed horizontally on the top of the filament, one end of which bears an anther lobe containing pollen, the other merely a petaloid plate or abortive anther lobe; it is then said to be *distractile.* Sometimes the connective is prolonged beyond the lobes of the anther; either as a little rounded or tapering cellular expansion, as in Magnolia (*fig.* 513), Asarum, &c., or as a long feathery process, as in the Oleander (*Nerium Oleander*) (*fig.* 515), and in various other ways. At other times again, it is prolonged downwards and backwards as a kind of spur, as in the Heartsease (*fig.* 514), &c. Anthers with such appendages are termed *appendiculate.*

Form of the Anther Lobes, and Anther.—The lobes of the anther assume a variety of forms. Thus in *Mercurialis annua* (*fig.* 517), they are somewhat *rounded*, very frequently, they are more or less *oval*, as in the Almond (*fig.* 518), in the *Acalypha*, they are *linear* (*fig.* 516), in the Gourd tribe

Fig. 516. *Fig.* 517. *Fig.* 518. *Fig.* 519.

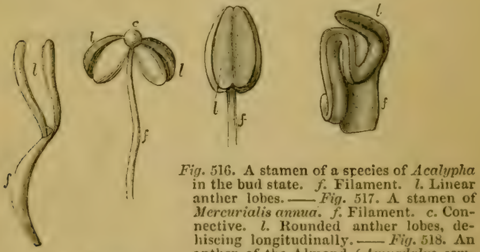


Fig. 516. A stamen of a species of *Acalypha* in the bud state. *f.* Filament. *l.* Linear anther lobes.——*Fig.* 517. A stamen of *Mercurialis annua*. *f.* Filament. *c.* Connective. *l.* Rounded anther lobes, dehiscing longitudinally.——*Fig.* 518. An anther of the Almond (*Amygdalus communis*), with oval lobes *l.* *f.* Filament.——*Fig.* 519. The linear and sinuose anther lobes *l*, attached to the filament of the common Bryony (*Bryonia dioica*). The above figures are from Jussieu.

(*fig.* 519) *linear*, and *sinuose* or *convoluted*, in the *Solanum* four-sided, and at other times pointed, or prolonged in various ways. These forms combined with those of the connective determine that of the anther; which may be oval, oblong, &c.; or *bifurcate* or *forked*, as in the *Vaccinium uliginosum* (*fig.* 521), or *quadrifurcate* (*fig.* 522), as in *Gualtheria procumbens*, or *sagittate* (*fig.* 515), as in the Oleander, or *cordate*, as in the common Wallflower (*figs.* 422 and 423); in the Grasses the anthers are bifurcate at each extremity (*fig.* 490), so as to resemble somewhat the letter x in form.

The lobes of the anther also, like the connective, frequently

present appendages of various kinds. Thus in the *Erica cinerea* (*fig.* 520, *a*) they have a flattened leafy body at their base; at other times the surface of the anther presents projections in the shape of pointed bodies (*fig.* 521, *a*), as in *Vaccinium uliginosum*, or warts, &c. Such anthers like those which present appendages from the connective are termed *appendiculate.*

Fig. 520. *Fig.* 521. *Fig.* 522.

Fig. 520. Appendiculate anther attached to filament, *f*, of the Fine-leaved Heath (*Erica cinerea*). *a*. Appendix. *l*. Lobes. *r*. Lateral pore or slit where dehiscence takes place.——*Fig.* 521. Bifurcate anther of *Vaccinium uliginosum* attached to filament *f*. *l*. Anther lobes. *a*. Appendages. *p*. Points of the anther lobes where dehiscence takes place.——*Fig.* 522. Quadrifurcate anther of *Gaultheria procumbens*, attached to filament *f*. *l*. Anther lobes. The above figures are from Jussieu.

The anther when young is of a greenish hue, but when fully matured it is usually yellow. There are however many exceptions to this; thus it is dark purple, or black, in many Poppies, orange in *Eschscholtzia*, purple in the Tulip, red in the Peach, &c.

Dehiscence.—When the anthers are perfectly ripe they open and discharge the pollen contained within them; this act is called the *dehiscence* of the anther. It usually takes place at the period when the flower is expanded, and the pistil consequently fully developed to receive the influence of the pollen; at other times however, the anthers burst before the flower opens and while the pistil is still in an imperfect state. All the anthers may open at the same period, or in succession; and in the latter case the dehiscence may either commence with the outer stamens, or with the inner. Thus according to Vaucher, in *Helleborus* the outer stamens open their anthers first, and those in the centre last; while in *Glaucium* the inner stamens open first, and those of the circumference last. In the common Rue (*Ruta graveolens*) again, there are two whorls of stamens, the outer stamens incline towards the pistil first and discharge their pollen, and then return to their former position; the inner stamens then incline and discharge their pollen in a similar manner. Sometimes, as in *Parnassia palustris*, each stamen curves in succession towards the pistil, when the anthers open and emit the pollen. Usually the outer stamens are those which dehisce first.

The dehiscence is produced, partly by the development and growth of the pollen in the anthers pressing upon the walls and causing an absorption of their tissue; and partly by the special action of the fibrous tissue which forms the lining of the anther. Thus we have already seen that the endothecium is composed of fibrous cells and that it is altogether wanting at the sutures, and that the exothecium is also commonly very thin at those points. The manner in which the fibrous layer acts is thus stated by Jussieu :—"The small, very elastic hygrometric threads or bands constituting this layer, stretch, contract, lengthen, and bend in different ways, according as the anther is dry or moist; and these variations are influenced, on the one hand by the development of the anther, the juices of which, at first abundant, are absorbed and evaporated by degrees; on the other hand, by the variable state of the atmosphere. The tissue which forms the wall of the anther, thus subjected to a series of forces acting in different directions, naturally breaks where it offers but little resistance, that is, at the line or the point where the fibrous layer is interrupted; and it is thus that the loculus splits and communicates with the exterior, so as to allow the free egress of the pollen enclosed in the cavity, an egress, which the continual contractions of the elastic tissue favour, and then complete."

The dehiscence may take place in four different ways, which are called, 1. *Longitudinal*, 2. *Transverse*, 3. *Porous*, 4. *Valvular.*

Fig. 523.

Fig. 523. Stamen of the Mallow (*Malva*), the anther of which has an apparently transverse dehiscence.

1. *Longitudinal* dehiscence. This the usual mode, consists in the opening of each anther lobe from the base to the apex in a longitudinal direction along the line of suture, as in Wallflower (*fig.* 423) and Buttercup.

2. *Transverse.*—This kind of dehiscence mostly occurs in unilocular anthers, as those of *Alchemilla* (*fig.* 504), *Lemna*, *Lavandula*, &c. It signifies that the splitting open of the anther occurs in a transverse or horizontal direction, i.e. from the connective to the side. It sometimes happens that by the enlargement of the connective the loculus of a one-celled anther is placed horizontally instead of vertically, in which case the dehiscence when it takes place in the line of the suture would be apparently transverse, although really longitudinal. An example of this kind of dehiscence is afforded by the Mallow (*Malva*), and other allied plants (*fig.* 523).

3. *Porous or Apical.*—This is a mere modification of longitudinal dehiscence. It is formed by the splitting down of the anther lobes being arrested at an early period

Fig. 524. *Fig.* 525. *Fig.* 526. *Fig.* 527. *Fig.* 528.

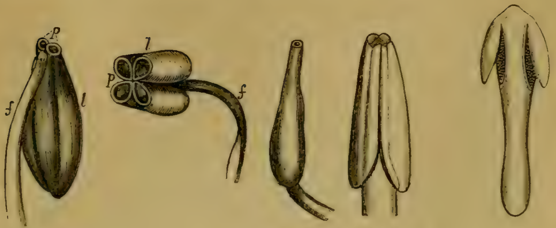


Fig 524. Anther of the *Pyrola rotundifolia*, suspended from the filament *f*. *l*. Loculi opening by two pores *p*. —— *Fig*. 525. Quadrilocular anther of *Poranthera*, attached to filament *f*. *l*. Loculi opening by pores *p*. —— *Fig*. 526. Anther of *Tetratheca juncea*, opening by a single pore at the apex. These figures are from Jussieu. —— *Fig*. 527. Anther lobes of a species of Nightshade opening by pores at the apex. —— *Fig*. 528. Anther of Barberry (*Berberis vulgaris*) opening by two valves.

Fig. 529.

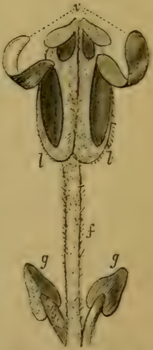


Fig. 529. Stamen of a species of Laurus. *f*. Filament, with two glands *g*, *g* at its base. *l*, *l*. Loculi of which there are four. *v*. Valves.

so as only to produce pores or short slits (*figs*. 524—527). In such anthers there is commonly no trace of the sutures to be seen externally. The pores or slits may be either situated at the apex, as in the Nightshade (*Solanum*) (*fig*. 527), or laterally, as in the Heaths (*fig*. 520). There may be either two pores, as is usually the case (*fig*. 524), or four, as in *Poranthera* (*fig*. 525), or many, as in the Mistletoe, or only one, as in *Tetratheca juncea* (*fig*. 526).

4. *Valvular*.—This name is applied when the whole or portions of the face of the anther open like trap-doors, which are attached at the top and turn back as if on a hinge. In the Barberry (*Berberis*) (*fig*. 528) there are but two such valves, while in the Sassafras and other plants belonging to the Laurel family, there are four, that is, two to each lobe, placed in pairs one over the other (*fig*. 529).

The Stamens generally or the Andrœcium.—Having now described the two parts of the stamen and the matters generally connected with their development, we have in the next place to take a view of the stamens of the flower collectively, in their relations to each other, and to the other whorls of the flower. We shall consider this part of our subject under

four heads, namely : — 1. Number, 2. Insertion or Position, 3. Union, 4. Relative length.

1. *Number.*—The number of stamens in the flower is subject to great variation, and several terms are in common use to indicate them.

In the first place, certain names are applied to define the number of the stamens when compared with the sepals and petals. Thus when the stamens are equal in number to the sepals and petals, the flower is said to be *isostemenous*, as in the Primrose ; if they are unequal, as in the Valerian the flower is *anisostemenous*, or when greater accuracy is required in the latter case, we say *diplostemenous*, if the stamens are double the number, as in Stonecrop, *meiostemenous*, if less in number, as in the Lilac, and *polystemenous*, if more than double, as in the Rose.

Secondly, the flower receives different names according to the actual number of stamens it contains, without reference to the outer whorls. This number is indicated by the Greek numerals prefixed to the word *androus*, which means male or stamen. Thus :—

A flower having One stamen is Monandrous, as in Hippuris.
„ „ Two stamens is Diandrous, as in the Ash and Privet.
„ „ Three stamens is Triandrous, as in most Grasses.
„ „ Four stamens is Tetrandrous, as in the Holly and Plantain.
„ „ Five stamens is Pentandrous, as in the Cowslip and Convolvulus.
„ „ Six stamens is Hexandrous, as in the Lily and Tulip.
„ „ Seven stamens is Heptandrous, as in the Æsculus and Trientalis.
„ „ Eight stamens is Octandrous, as in the Ivy and Heaths.
„ „ Nine stamens is Enneandrous, as in the Flowering Rush.
„ „ Ten stamens is Decandrous, as in the Pink and Saxifrage.
„ „ Twelve stamens is Dodecandrous, as in the Asarabacca,
„ „ Twenty stamens is Icosandrous, as in the Strawberry.
„ „ Numerous stamens is Polyandrous, as in the Poppy and Water-Lily.

We shall have to refer to these terms again when treating of the Linnæan system of classification as some of the classes in

that arrangement are determined by the number of stamens contained in the flower.

2. *Insertion or Position.*—When the stamens are free from the calyx and pistil, and arise from the thalamus or torus below the latter organ, as in the Poppy (*fig.* 428), and Ranunculus (*fig.* 520), they are said to be *hypogynous*, which signifies under the female or pistil; this is the normal position of the stamens. When they are attached to the corolla, as in the Primrose (*fig.* 531), they are *epipetalous*; this is commonly the case when the corolla is *monopetalous*. The insertion of the stamens is always regarded as the same as that of the corolla, so that when the former organs are epipetalous their insertion with regard to the pistil depends upon the point where the corolla itself becomes free; thus, in the Primrose (*fig.* 531), where the stamens are epipetalous and the corolla arises from below the pistil and free from the calyx, the stamens, as well as the corolla, are said to be *hypogynous*. When the stamens adhere to the calyx more or less, so that their position becomes somewhat lateral to the pistil instead of below it, as in the Strawberry, Cherry (*fig.* 532), and Apricot, they, as well as the corolla are said to be *perigynous*. When the calyx is adherent to the ovary so that it appears to arise from its apex, the intermediate stamens and corolla also arise from the summit, and are said to be *epigynous*, as in the Campanula (*fig.* 533), Epilobium, Carrot, Ivy, &c.

Fig. 530.

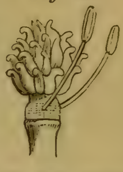


Fig. 530. Apocarpous pistil of Ranunculus, with two stamens arising from the thalamus below it.

Fig. 531.

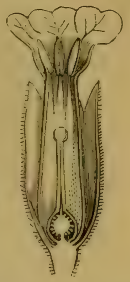


Fig. 531. Vertical section of a flower of the Primrose (*Primula*), showing epipetalous stamens. The pistil in the centre has an ovary with a free central placenta, a style, and a capitate stigma.

Fig. 532.

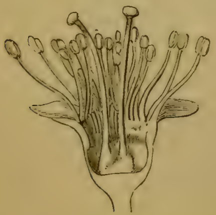


Fig. 533.

Fig. 532. Vertical section of the flower of the Cherry, showing the perigynous stamens surrounding the pistil. —— *Fig.* 533. Vertical section of a flower of Campanula, with epigynous stamens.

The full understanding of the above terms is of great importance in practical botany, and the arrangements of the organs as thus indicated by them, have been used by DeCandolle and others as the basis of some of their sub-divisions in their systems of classification. Thus the term *thalamifloræ* is applied to plants which have polypetalous corollas, and *hypogynous* stamens unconnected with the other whorls, as in the Poppy (*fig.* 428) and Ranunculus (*fig.* 530). When the corolla is polypetalous, and the stamens are attached with it to the calyx, as in the Cherry (*fig.* 532), or upon the top of the ovary, as in Campanula, &c. (*fig.* 533), the term *calycifloræ* is given. When the corolla is monopetalous, as in Primrose (*fig.* 531), the term *corollifloræ* is applied. These terms will be more particularly described hereafter when treating of Systematic Botany.

Fig. 534.

Fig. 535.

Fig. 534. Flower of *Orchis mascula*. The column in the centre is formed by the union of the stamens and style. —— *Fig.* 535. The pistil and stamens of Birthwort (*Aristolochia*). The ovary is seen below, and the stamens above united into a column with the style.

It sometimes happens that the stamens not only adhere to the ovary or lower part of the pistil, as in the epigynous form of insertion, but the upper part of the stamens and pistil become completely united also, and thus form a column in the centre of the flower, as in the Orchis (*fig.* 534), and Birthwort (*Aristolochia*) (*fig.* 535). The column is then termed the *gynostemium*, and the flowers are said to be *gynandrous*.

3. *Union*,—When the stamens are perfectly free and separate from each other, as in the Vine (*fig.* 506), they are said to be *free* or *distinct*; when united, as in the Mallow (*fig.* 537), they are *coherent* or *connate*.

This union may take place, either by their anthers, or by their filaments. When the anthers cohere, the filaments being free, the stamens are termed *syngenesious* or *synantherous* (*fig.* 536). This union occurs in all the Compositæ, in the Lobelia, Violet, &c. When union occurs between the stamens however, it is more common to see the filaments unite, and the anthers free. The union by the filaments may take place in one or more bundles, the number being indicated by a Greek numeral prefixed to the word *adelphous*, which signifies *brotherhood*. Thus, when all the filaments unite together and form one bundle, as in the

Fig. 536.

Fig. 537.

Fig. 538.

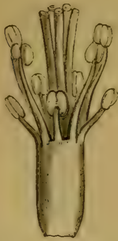


Fig. 539.

Fig. 536. Syngenesious anthers of a species of Thistle. —— *Fig.* 537. Monadelphous stamens of Mallow (*Malva*). —— *Fig.* 538. Monadelphous stamens of Oxalis forming a tube round the pistil. —— *Fig.* 539. Male flower of *Jatropha Curcas*. *c.* Calyx. *p.* Corolla. *e.* Stamens united by their filaments into a tube, *a*, which occupies the centre of the flower as there is no pistil.

Mallow (*fig.* 537), and Oxalis (*fig.* 538), the stamens are *monadelphous*. When this union takes place in a complete flower, the coherent filaments necessarily form a tube or ring round the pistil placed in their centre, as in the Oxalis (*fig.* 538). When the pistil is absent, and the flower incomplete, the united filaments form a more or less central column, as in *Jatropha Curcas* (*fig.* 539 *a*). When the filaments unite so as to form two bundles, the stamens are termed *diadelphous*, as in the Pea (*fig.* 540), Fumitory (*fig.* 856), &c., in which case the number of filaments in each bundle may be equal, as in the Fumitory (*fig.* 856, or unequal, as in the Pea (*fig.* 540). The latter plant has a papilionaceous corolla with ten stamens, and in such flowers it frequently happens, that the filaments are so united, that nine of them form a bundle, while one remains free (*fig.* 540). When the stamens are united by their filaments into three bundles, they are *triadelphous*, as in some species of St. John's Wort (*Hypericum*) (*fig.* 542); when in more than three, *polyadelphous*, as in the Castor Oil plant (*Ricinus*) (*fig.* 543), Orange (*fig.* 541), and

Fig. 540.

Fig. 540. Diadelphous stamens of the Sweet Pea (*Lathyrus*), surrounding the pistil. There are ten stamens, nine of which are united and one free.

Fig. 541.

Fig. 542.

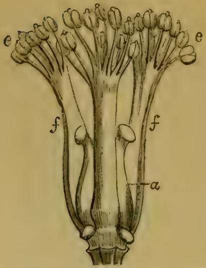


Fig. 543.

Fig. 541. Flower of Orange divested of the corolla, showing polyadelphous stamens.——*Fig.* 542. The Pistil, *a*, of a species of *Hypericum*, surrounded by the stamens, *e*, which are united by their filaments, *f*, into three bundles. ——*Fig.* 543. One of the branched bundles of stamens of the Castor Oil Plant (*Ricinus communis*).

some species of St. John's Wort (*Hypericum Androsæmum*); the term polyadelphous is applied by many botanists, in all cases where there are more than two bundles of stamens.

The union of the filaments in the above cases, may either take place more or less completely, and thus form a tube of varying heights. as in the Mallow (*fig.* 537), Oxalis (*fig.* 538), Hypericum, &c.; or the union may only take place at the base, as in Tamarix (*fig.* 491). The bundle or bundles, again, may be either simple, as in the Mallow, &c.; or branched, as in Polygala (*fig.* 503), and Castor Oil Plant (*fig.* 543).

Fig. 544.

Fig. 544. Flower of Valerian, showing the stamens prolonged beyond the tube of the corolla or exserted. The corolla is gibbous or saccate at the base.

When the union takes place so as to form a tube or column, the term *androphore* has been applied to the body thus formed, as in the Mallow (*fig.* 537), Oxalis (*fig.* 538), &c.

4. *Relative Length.*—There are two separate subjects to be treated of here, namely, 1st, the relative length of the stamens with respect to the corolla; and 2nd, with respect to each other. In the first place, when the stamens are shorter than the tube of the corolla so as to be enclosed within it, as in the Forget-me-not (*Myosotis*) (*fig.* 496), and in the Peruvian Bark plant (*Cinchona*), they are said to be *included;* when, on the contrary, the stamens are longer than the tube of the corolla so as to extend beyond it, as in the Valerian (*fig.* 544), Plantain, Exostemma, &c., they are *exserted* or *protruding*.

The relative length of the stamens with

respect to each other presents several peculiarities, some of which are important in descriptive botany. Sometimes, all the stamens of the flower are nearly of the same length, while at other times, they are very unequal. This inequality may be altogether irregular again, following no definite rule, or take place in a definite and regular manner. When the flowers are polystemenous, the stamens nearest the centre may be longer than those at the circumference, as in Luhea (*fig.* 545), or the reverse may be the case, as in many of the Rosaceæ. In the case of diplostemenous flowers, as in Epilobium, the stamens alternating with the petals are almost always longer than those opposite to them.

Fig. 545.

Fig. 546.

Fig. 547.

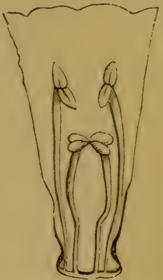


Fig. 545. One of the bundles of stamens of *Luhea paniculata*, the inner stamens on the right are longer than the others and are provided with anthers: the others are shorter and generally sterile. —— *Fig.* 546. Tetradynamous stamens of the Wallflower (*Cheiranthus Cheiri*). —— *Fig.* 547. Didynamous stamens of the Foxglove (*Digitalis purpurea*).

When there is a definite relation existing between the long and short stamens with respect to number, certain names are applied to indicate such forms of regularity. Thus in the Wallflower (*fig.* 546), and Cruciferous Plants generally, there are six stamens to the flower, of which four are long and arranged in pairs opposite to each other, and alternating with two solitary shorter ones; to such an arrangement we apply the term *tetradynamous*. When there are but four stamens, of which two are long, and two short, as in Labiate Plants generally (*figs.* 471 and 473), and in the Foxglove (*fig.* 547) and many other Scrophulariaceous Plants, they are said to be *didynamous*; in this arrangement the two long stamens correspond to the upper lip of the corolla, while the two short ones are more or less lateral.

THE POLLEN.—We conclude our notice of the stamens by describing the nature of the pollen.

Development and Structure.—We have already seen (p. 248), that the pollen corresponds to the cellular tissue of the leaf situated between the epidermis of the upper and lower surfaces. It has also been stated, that the pollen was formed in certain cells developed originally in the centre of the parenchyma of the young anther (*fig.* 500, *cm*); also that these cells were enclosed in a special covering of their own (*fig.* 500, *cl*), and that in the course of growth they pressed upon the surrounding parenchyma, *ci*, so as to cause its more or less complete absorption, and finally assisted in promoting the dehiscence of the anther. We have now more particularly to describe the mode of development and the structure of the pollen.

The formation of the pollen has been already described under the head of *Cell-division with absorption of the walls of the parent cell, and the setting free of the new cells* (see p. 60). We will however recapitulate the principal points connected with this subject. The large cells (*fig.* 500, *cm*) which are developed in the parenchyma of the young anther and which are destined for the formation of the pollen, are called *parent* or *mother* cells: the primordial utricle of each of these becomes infolded as in ordinary cell-division so as to divide it into four portions, either directly, or indirectly by first dividing it into two, and then each of these being again divided into two others; these four portions are called *special parent* or *mother cells;* the whole of the protoplasmic contents in each cell then secretes a layer of membrane on its outside, and we have thus four perfect cells (*fig.* 144, *a, b, c, d*) formed in the cavity of the parent cell, which constitute the true *pollen-cells;* as these progress in development, one or more layers are formed with a few exceptions on the outside of their original membrane, which ultimately exhibits markings and projections of various kinds (*figs.* 11, 553, &c.), the nature of which varies in the pollen of different species, but is always the same in any particular one. The four pollen-cells continuing to increase in size, distend the parent cell and ultimately cause its absorption; and subsequently the special mother cells are generally absorbed also, by which the pollen-cells or grains are set free in the loculus of the anther in their perfect condition. Sometimes the membrane of the special parent cells is not completely absorbed, in which case the pollen-grains of the parent are more or less connected, and

Figs. 548. and 549.

Fig. 548. Pollen of *Periploca græca.* —*Fig.* 549. Pollen of *Inga anomala.* After Jussieu.

form a compound body consisting of four pollen-grains, as in *Periploca græca* (*fig.* 548); or if the membranes of two or more united parent cells are also incompletely absorbed, we may have a mass consisting of eight pollen-grains, as in *Inga anomala* (*fig.* 549), or of some multiple of four, as in many Acacias (*fig.* 12). By some botanists, the union of the pollen-grains in the above instances, is referred simply to the viscid secretion left in such cases by the solution of the parent cells, but their regular arrangement in fours or multiples of four, would seem to prove that the special mother cells are more particularly concerned in the formation of such compound pollen-grains, in the manner just described. In the Onagrariaceæ, the pollen-grains are loosely connected by long viscid filaments or threads, which seem in this case to be wholly derived from a secretion left by the solution of the parent cells. In the Orchidaceæ (*fig.* 550), the pollen-grains cohere in a remarkable degree and form pollen masses which are commonly of a waxy nature, to which the name of *pollinia* has been given. In the Asclepiadaceæ somewhat similar masses occur (*fig.* 551); in

Fig. 550.

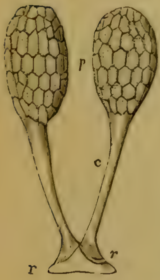


Fig. 551.

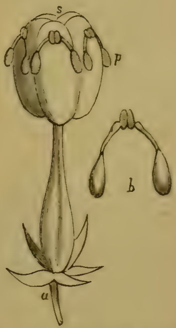


Fig. 552.

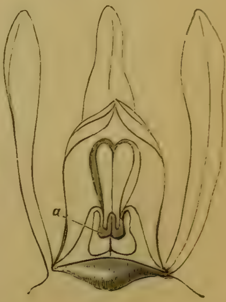


Fig. 550. Pollinia, *p*, of Orchis with their caudicles, *c*, and the retinacula, *r*, at the base.——*Fig.* 551. Pistil of Asclepias, with the pollinia, *p*, adhering to the stigma, *s*. *b*. Pollen masses separated.——*Fig.* 552. Upper part of the flower of an Orchis, showing the pollinia adhering to the stigma by the retinacula, *a*.

the latter however, the whole pollinia is invested by a special cellular covering. By a careful examination of these pollinia, we find that they are formed of compound masses agglutinated together, and when separated, each of these is found to consist of four pollen-grains. In the pollinia of the Orchidaceæ we also find other peculiarities; thus, each is prolonged downwards in the

form of a stalk called the *caudicle* (*fig.* 550, *c*), which adheres commonly at the period of dehiscence to one or two little glandular masses called *retinacula* (*figs.* 552, *a*, and 550, *r*), which are placed on the upper surface of a little projection called the *rostellum* situated at the base of the anther.

We must now return to the more particular description of the pollen-grain or cell. We shall treat of it under four heads, viz.: – 1. Its Wall or Coats; 2. Its Contents; 3. Its Form and Size; and 4. Its Dehiscence.

1. *Wall or Coats of the Pollen-cell or grain.*—When perfectly ripe the wall of the pollen-grain generally consists of two membranes; an internal or *intine*, and an external or *extine.* In rare cases the outer coat appears to consist of two, or even three layers; while in *Zostera*, *Zannichellia*, and some other submerged aquatic plants, there is but one membrane, which is of a similar nature to the intine.

The *intine* is the first formed layer, and appears to be of the same nature and appearance in all pollen-grains. It is usually smooth, very delicate, and transparent. It is generally applied so as to form a complete lining to the extine, except perhaps in those cases where the latter presents various processes, as in *Œnothera*, when Henfrey believes that the intine does not extend into them in the mature pollen.

The *extine* is a hard thick resisting layer forming a kind of cuticle over the intine. While the intine always presents a similar appearance in the pollen of different plants, the extine is liable to great variation, thus it is sometimes smooth; at other times marked with little granular processes (*fig.* 553), or spiny protuberances, or reticulations, &c. The nature of these markings as already noticed, is always the same for any particular species of plant, but varies much in different species; the mode in which they originate is at present unknown. The outer coat is generally covered by a viscid or oily secretion, which is supposed by some, to be derived from matter remaining from the solution of the parent cells. The colour of pollen-grains also resides in the extine. In by far the majority of cases the pollen-cells are yellow, but various other colours are found; thus they are red in the *Verbascum*, blue in some species of *Epilobium*, black in the Tulip, rarely green, and occasionally of a whitish tint.

Fig. 553.

Fig. 553. Pollen of Hollyhock (*Althæa rosea*).

Besides the various markings just described as existing on the extine, we find also, either *pores* (*fig.* 556), or *slits* (*figs.* 554 and 555), or both together, and which vary in number and arrangement in different plants. At the spots where these slits or pores are found, it is generally considered that the extine is

Fig. 554.

Fig. 555.

Fig. 556.

Fig. 554. Elliptical pollen of Milkwort (*Polygala*) *e*. Extine. *f*. Slits. —— *Fig.* 555. The same pollen viewed from above. —— *Fig.* 556. Pollen-grain of *Dactylis glomerata*. After Jussieu.

absent; but other botanists on the contrary, believe that the outer membrane always exists, but that it is much thinner at these points than elsewhere. In the greater number of Monocotyledonous Plants, there is but one slit; while, on the contrary, three is a common number in Dicotyledons. Sometimes there are six, rarely four, still more rarely two, and in some cases we find twelve or more. These slits are generally straight, but in *Mimulus moschatus* they are curved; and other still more complex arrangements occasionally occur.

The pores like the slits, also vary as to their number. Thus we commonly find one in Monocotyledons, as in the Grasses, and three in Dicotyledons, Sometimes again, the pores are very numerous, in which case, they are either irregularly arranged, or in a more or less regular manner. The pores, again, may be simple, or provided with little lid-like processes which are pushed off at the period when the pollen-grains dehisce, as in the Passion-flower (*fig.* 557, *o*, *o*, *o*), and Gourd (*fig.* 558); hence such pollen-grains have been termed *operculate*.

Fig. 557.

Fig 558.

Fig. 559.

Fig. 557. Pollen of a Passion-flower (*Passiflora*), before bursting. *o*, *o*, *o*. Lid-like processes. —— *Fig.* 558. Pollen of the Gourd, at the period of dehiscence. *o*, *o*. Lid-like processes of the extine protruded by the projections *t*. *t*, of the intine. From Jussieu. —— *Fig.* 559. Trigonal pollen of the Evening Primrose (*Œnothera biennis*).

2. *Contents of the Pollen-grains, or Fovilla.*—The matter contained within the membranes of the pollen-grains is called the *fovilla*. It is a semifluid granular protoplasm in which are suspended very small starch granules, and what appear to be oil globules. As the pollen approaches to maturity, the fovilla

becomes more concentrated, and contains less fluid matter and more granules. Some of these granules are said to be no more than about $\frac{1}{30000}$ of an inch in diameter, while the largest are about $\frac{1}{4000}$ or $\frac{1}{5000}$. They vary also in form, some being spherical, others oblong, and others more or less cylindrical with somewhat tapering extremities. When water is applied to the granular contents they become opaque. When viewed under a high magnifying power, the starch granules at certain periods (especially at the period of dehiscence), exhibit a very active tremulous motion, moving to and fro in various directions and appearing as if repelled by each other. This is simply molecular motion, analogous to that of all other very minute particles when suspended in a liquid. The fovilla is without doubt the essential part of the pollen-grain, but the office it performs will be explained hereafter.

3. *Form and Size of the Pollen.*—Pollen-grains are found of various forms. The most common appear to be the spherical (*fig.* 557), and oval (*fig.* 554); in other cases they are polyhedral, as in Chicory and *Sonchus palustris*, or triangular with the angles rounded and enlarged (trigonal), as in the Evening Primrose and plants generally of the order Onagrariaceæ (*fig.* 559), or cubic, as in *Basella alba*, or cylindrical, as in the *Tradescantia virginica*, while in Zostera, they are thread-like or of the form of a lengthened tube or cylinder. It should be noticed that the form of the pollen is materially influenced according as it is dry or moist. Thus the pollen-grains of the Purple Loosestrife and some species of Passion-flower are oval when dry, but when placed in water they swell and become nearly globular: this arises from endosmotic action taking place between the thickened fovilla and the water, by which some of the latter is absorbed, and the pollen consequently distended. Again, when spherical pollen-grains are exposed to the air for some time they frequently assume a more or less oval form. In size, pollen-grains vary from about $\frac{1}{200}$ to $\frac{1}{1000}$ of an inch in diameter; their size however like their form, is liable to vary according as they are examined in a dry state or in water.

4. *Dehiscence of the Pollen.*—We have already stated, that when the pollen-grains are placed in water they become distended in consequence of endosmotic action taking place between their thickened contents and the surrounding fluid. If this action be continued by allowing the pollen-grains to remain in the liquid, they must necessarily burst at some point or other, and allow their contents to escape. As the intine is very extensible, while the extine is firm and resisting, it will be found that the former will form little projections through the pores or slits of the latter (*fig.* 560), so as to produce little blister-like swellings on its surface. Ultimately, however, as absorption of fluid by endos-

mose still goes on, the intine will itself burst and discharge the contents of the pollen-grain in the form of a jet (*fig.* 560). These changes take place more rapidly, if a little sulphuric or nitric acid be first added to the water.

When the pollen is thrown upon the stigma under natural circumstances at the period of the dehiscence of the anthers, the above-described action becomes materially modified. Here, the pollen-grain does not burst, but its intine protrudes through one or more of the pores or slits of the extine in the form of a delicate tube (*figs.* 561 and 562) filled with the fovilla,

Fig. 560.

Fig. 561.

Fig. 562.

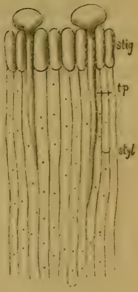


Fig. 560. Pollen of Cherry discharging its fovilla through an opening in the intine.——*Fig.* 561. Trigonal pollen of *Œnothera* with a pollen-tube.——*Fig.* 562. Vertical section of the stigma and part of the style of *Antirrhinum majus*. *stig.* Stigma, on which two pollen-grains have fallen, each of which is provided with a pollen-tube, *tp*, which pierces the tissue of the style, *styl.*

and called the *pollen-tube;* this penetrates (as will be afterwards described) through the tissue of the stigma and style to the ovules. This tube is frequently some inches in length, and its formation is not due as was formerly supposed to endosmotic action, but it is a true growth like that of a seed germinating, and caused by the nourishment it derives from the stigma and style.

2. The Disk.

By the disk, we understand all bodies of whatever form, which are situated on the thalamus between the stamens and the ovary, but which cannot be properly referred to either of those organs. This is the sense in which it is properly applied, but by some botanists the term is understood as synonymous with torus, and defined as that part of the receptacle

or thalamus which is situated between the calyx and the pistil, and which forms a support to the corolla and stamens; while others, again, define the disk as the portion of the torus situated between the calyx and pistil, when that part assumes an enlarged or irregular appearance. Here the term torus is used in the sense in which we apply it in that volume, *i.e.*, synonymous with thalamus and receptacle, but the application of the term disk is more extended than in our definition.

The disk is not to be considered as an essential organ, although it is properly treated of in this place, as it comes next in order to the stamens as we proceed with our examination of the parts of the flower. The disk seems, in many cases at least, to be merely a modification of the stamens, which appears to be proved, not only from its parts occasionally alternating with them, as in *Gesnera*, &c, but also from the circumstance of portions of it when highly developed becoming occasionally changed into stamens. It is frequently of a nectariferous nature, and hence was treated of by Linnæus and many succeeding botanists, under the head of nectaries.

Fig. 563.

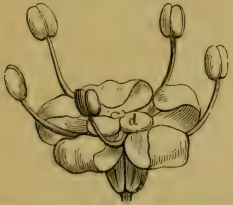


Fig. 564.

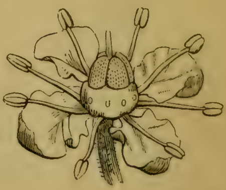


Fig. 563. Flower of the Fennel (*Fœniculum*). The ovary is surmounted by a disk, *d.* —— *Fig.* 564. Flower of the Rue (*Ruta graveolens*). The pistil is surrounded by a disk in the form of a fleshy ring, on the outside of which the stamens are inserted.

Fig. 565.

Fig. 565. Pistil of the Tree Pæony invested by a large cup-shaped disk.

The disk is developed in a variety of forms; thus in the Orange and Rue (*fig.* 564) it forms a fleshy ring surrounding the base of the pistil; in the Tree Pæony (*fig* 565), a dark red cup-shaped expansion covering nearly the whole of the pistil except the stigmas; in the Rose and Cherry, a sort of waxy lining to the tube of the calyx; in Umbelliferous Plants, a swelling on the top of the ovaries adhering to the styles (*fig.* 563, *d*), this form of disk has been termed the *stylopodium*. In other cases, the

disk is reduced to little separate glandular bodies, as in Cruciferous Plants (*fig.* 422, *gl*), Sedum, &c. (*fig.* 584); or to scales, as in the Vine (*fig.* 506); or to various petaloid expansions, as in the Aquilegia, Helicteres, &c.

When the disk is situated under the ovary, as in the Orange, Rue, Wallflower, Helicteres, &c., it is termed *hypogynous;* when it is attached to the calyx, as in the Rose, Cherry, &c., it is *perigynous;* or when on the summit of the ovary, as in Umbelliferous plants, *epigynous.* These terms being used in the sense already described when treating of the insertion of the stamens under the head of the Andrœcium.

The so-called nectaries are by some botanists treated of in this place as distinct organs. We confine the meaning of the term nectary to those bodies which secrete a honey-like fluid, and have already referred to them under the heads of Glands and Corolla.

3. The Pistil or Gynœcium.

We now arrive at the consideration of the last organ which is present in the flower, namely the pistil or female system of flowering plants. The pistil occupies the centre of the flower, the stamens and floral envelopes being arranged around it when they are present (*fig.* 421); the envelopes alone in the pistillate flower; or it stands alone when the flower is pistillate and naked (*fig.* 392). It consists as we have seen, of one or more modified leaves called carpels, which are either distinct from each other, as in the Columbine (*fig.* 427), the Stonecrop (*Sedum*) (*fig.* 566); or combined into one body, as in the Tobacco (*Nicotiana Tabacum*) (*fig.* 568, 2), and Primrose (*Primula vulgaris*) (*fig.* 567). When there is but one carpel, as in the Pea, Broom, &c. (*fig.* 568), the pistil is said to be *simple;* when there is more than one, as in the Stonecrop and Primrose, it is *compound.* Before proceeding to examine the gynœcium

Fig. 566.

Fig. 567.

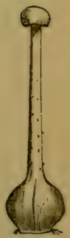


Fig. 568

Fig. 566. Pistil of Stonecrop (*Sedum*), consisting of five distinct carpels, on the outside of which at the base small scaly bodies may be noticed. The pistil is compound and apocarpous. —— *Fig.* 567. Pistil of Primrose (*Primula*), composed of several carpels united into one, hence termed compound syncarpous. There is but one style surmounted by a capitate stigma. —— *Fig.* 568. Simple pistil of Broom. *o.* Ovary. *s.* Style, *t.* Stigma.

Fig. 568, 2.

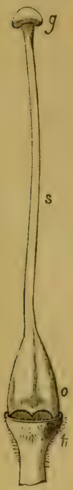


Fig. 569.

Fig. 569. Vertical section of the ovary of the Barberry (*Berberis vulgaris*), on the outside of which is seen a stamen and petal. *o*. Ovary: *ov*. Ovules attached to a projection called the placenta ; *st* Stigma.

Fig. 568, 2. Compound pistil of Tobacco (*Nicotiana Tabacum*) *t*. Thalamus. *o*. Ovary. *s*. Style. *g*. Capitate stigma.

or pistilline organs generally, it will be better for us in the first place, to describe the parts, nature, and structure of the simple carpel of which it is composed.

The Carpel.—This name is derived from a Greek word signifying the fruit, because the pistil forms as will be afterwards explained, the essential part of that organ. Each carpel, as we have already noticed, consists, 1st, of a hollow inferior part arising from the thalamus, called the Ovary (*fig.* 569, *o*), containing in its interior one or more little roundish or oval bodies called ovules *ov*, which ultimately become the seeds, and which are attached to a projection on the walls which is termed the *placenta*. 2nd. Of a stigma or space of variable size, composed of lax cellular tissue without epidermis ; it is either placed directly on the ovary, in which case it is said to be *sessile*, as in the Barberry (*Berberis vulgaris*) (*fig.* 569, *st*) ; or it is elevated on a stalk prolonged from the ovary, called the *style* (*figs.* 567 and 568 *s*). The only essential parts of the carpel, therefore, are the ovary and stigma, the style being no more necessary to it than the filament is to the stamen.

Fig. 570.

Fig. 570. Vertical section of the flower of the Pæony (*Pæonia*). *ds*. Dorsal suture of the ovary ; *vs*. Ventral suture.

The terms ovary, style, and stigma, are applied in precisely the same sense when speaking of a compound pistil in which the parts are completely united. The carpel has two sutures, one of which corresponds to the union of its margins, and which is turned towards the axis of the plant ; and another, which is directed towards the floral envelopes or to

the circumference of the flower ; the former is called the *ventral suture* (*fig.* 570. *vs*), the latter the *dorsal* (*fig.* 570 *ds*).

Nature of the Carpel.—That the carpel is analogous to the leaf is proved in various ways, some of which will be more particularly mentioned hereafter, when treating of the General Morphology of the Flower; we shall here only allude to the proofs of its nature which are afforded by tracing its development, and by the appearance it sometimes presents in double or cultivated flowers. Thus in the double flower of the Cherry, the carpels do not present a distinct ovary, style, and stigma, as in their normal condition in the single flower (*fig.* 574), but they, either become flattened into green expansions, each of which resembles the blade of a leaf (*fig.* 571), or into organs intermediate in their nature between carpels and leaves (*figs.* 572 and 573). Here the lower portion representing the

Fig. 571. *Fig.* 572. *Fig.* 573. *Fig.* 574.

Figs. 571, 572, and 573. Carpellary leaves from the double flowers of the Cherry tree. *l.* Lamina; *s.* Prolonged portion corresponding to the style and stigma of a perfectly formed carpel.——*Fig.* 574. Carpel from the single flower of the Cherry. *o.* Ovary; *t.* Style; *s.* Stigma.

lamina of the leaf, is clearly analogous to the ovary of a complete carpel, and the prolonged portion to the style and stigma. The carpels of the single-flowering Cherry being thus convertible into leaves, afford at once an evidence of their being analogous structures. A second proof of the nature of the carpels is afforded by tracing their development. Thus when first examined, they appear as little slightly concave bodies of a green colour like young leaves (*fig.* 575), in a short time they become more and more concave (*fig.* 576), till ultimately the two margins of the concavity in each unite, and

Fig. 575.

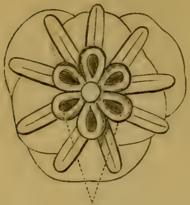


Fig. 576.

Fig. 577.

Fig. 575. Young flower-bud of the Flowering Rush (*Butomus umbellatus*). The carpels, *car*, are still concave on the inside and resemble small leaves. *Fig.* 576. The carpels in a more advanced state, but the folded edges still separated by a slit. —— *Fig.* 577. The same carpels in a perfect condition.

thus form a hollow portion or ovary, in which the ovules soon make their appearance (*fig.* 577). This gradual transition of little leafy organs into carpels may be well seen in the Flowering Rush (*Butomus umbellatus*). We have thus in the first place shown, that carpels become changed into leaves by cultivation, and secondly, that they make their first appearance in the form of little organs resembling leaves ; and in both ways, therefore, we have proofs afforded us of their leaf-like nature.

Fig. 578.

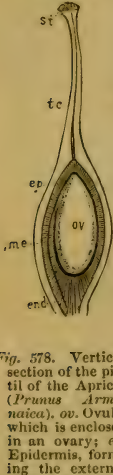


Fig. 578. Vertical section of the pistil of the Apricot (*Prunus Armeniaca*). *ov.* Ovule, which is enclosed in an ovary; *ep.* Epidermis, forming the external coat of the ovary; *me.* Middle layer; *end.* Inner coat; *tc.* Style with a canal in its centre ; *st.* Stigma.

Structure of the Carpel.—The *ovary* being the homologue of the lamina of the leaf, it presents, as might have been expected, an analogous structure. Thus it consists of parenchyma, which is often much developed, and through which vascular bundles composed of spiral and other vessels ramify, and converge towards the base of the style, or terminate at the upper part of the ovary when that is absent. The whole is covered externally by a layer of epidermis (*fig.* 578, *ep*). The parenchyma is usually of a more lax nature as we proceed towards the inside of the ovary, where it forms a very delicate lining, called *epithelium*, and which has been already described as a modified form of epidermis. This epithelium corresponds to the epidermis of the upper surface of the leaf, and being developed under the absence of light, it has usually a pale colour, and is devoid of stomata. The epidermis on the outside of the ovary corresponds to that of the lower surface of the leaf, and like it is frequently clothed with stomata, and

sometimes with hairs. The parenchyma between the epithelium and epidermis, *me.* corresponds to the general parenchyma of the leaf, which is similarly placed. Where the margins of the carpellary leaf meet and unite at the ventral suture, a layer of cellular tissue is developed, which forms a more or less projecting line in the cavity of the ovary, called the *placenta* (*fig.* 429, *p*), to which the ovules are attached. This placenta is essentially double, the two halves being developed from the two contiguous margins of the carpellary leaf.

The *style* has been considered by some botanists, as a prolongation of the midrib, but from the arrangement of its tissue it is to be regarded rather, as a prolongation of the whole of the upper portion of the lamina rolled inwards and united. It consists of a cylindrical process of parenchyma, traversed by distinct vascular bundles, which are arranged so as to form a sort of sheath at its circumference. These bundles are a continuation of those of the ovary, and proceed upwards without branching towards the apex of the style, but always terminate below that point. The style is invested by epidermis continuous with that of the ovary, and furnished occasionally like it, with stomata and hairs.

Upon making a transverse or vertical section of the style, we find that it is not a solid body as we might have supposed, but that it is traversed by a very narrow canal (*figs.* 580, *d*, and 578, *tc*), which communicates below with the cavity of the ovary, and above with the stigma. This canal is, either always entirely

Fig. 579.

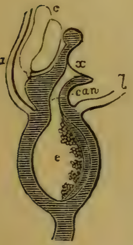


Fig. 580.

Fig. 581.

Fig. 579. Vertical section of the flower of *Epipactis latifolia*. *a.* One of the divisions of the perianth; *c.* Stamen; *e.* Ovules; *x.* Stigma; *can.* Canal leading from the stigma to the interior of the ovary. From Schleiden.——*Fig.* 580. Transverse section of the style of the Crown Imperial (*Fritillaria imperialis*). *d.* Canal in its centre lined by projecting papillæ. From Jussieu.——*Fig.* 581. Section showing the structure of the canal of the style in Campanula. From Jussieu. *c, c.* parenchymatous cells forming its walls, traversed by spiral vessels, *v*; *p, p.* variously-formed loosely aggregated cells; *f, f.* elongated filiform cells, which with the former more or less obstruct the canal.

open; or more or less obstructed, as in Orchids (*fig.* 579, *can*), or somewhat filled up by a number of very loosely aggregated cells (*fig.* 581, *p p*). The walls of the canal also, in all cases, are formed of a loose papillose parenchyma (*fig.* 581, *cc*). This canal may be considered as a prolongation of the cavity of the ovary in an upward direction, consequently the loose tissue by which it is surrounded is to be regarded as corresponding to the epidermis of the upper surface of the leaf, merely modified to adapt itself to the peculiar conditions under which it is placed, in the same way as is the case with the epithelium forming the lining of the ovary. When the pistil is fully matured, or at the period when it is adapted for receiving the influence of the pollen, the canal of the style becomes further obstructed by a number of lengthened filiform cells (*fig.* 581, *f, f*), which have been sometimes confounded with pollen-tubes, but from which they are readily distinguished by being twice or three times their diameter. At the period of fecundation, these cells as well as those of the stigma and canal of the style generally, secrete a peculiar viscid fluid containing gum or sugar, or both, called the stigmatic fluid. The loose tissue which thus lines the canal of the style, with the filamentous elongated cells which are developed in it at the period of fecundation, and the secreted fluid, together form a very loose humid tissue, to which the name of *conducting tissue* has been given, because from its loosened nature and nourishing properties it serves to conduct the pollen-tubes down the styles to the ovules, as will be explained hereafter.

Fig. 582. *Fig.* 583. *Fig.* 584.

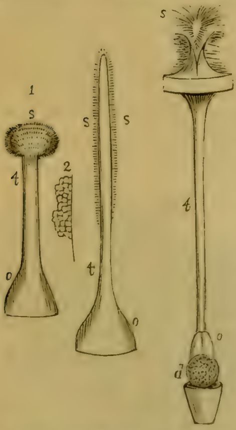


Fig. 582. 1. A portion of the pistil of *Daphne Laureola*. *o.* summit of the ovary; *t.* style terminated by a stigma *s.* 2. a portion of the stigma highly magnified, showing its papillose nature.—— *Fig.* 583. A portion of the pistil of *Plantago saxatilis*. *o.* summit of the ovary; *t.* style; *s, s.* bilateral stigma. The above are from Jussieu. —— *Fig.* 584. Pistil of the Periwinkle (*Vinca*). *o.* ovary; *t.* style; *s.* hairy stigma; *d.* disk.

The Stigma.—The tissue of the stigma is analogous to that found in the interior of the style, and just described under the name of conducting tissue; in fact, it seems to be nothing more than an expansion of this externally. It may be either on one side of the style (*figs.* 585 and 587), or at its apex (*fig.* 582), or even on both sides (*fig.* 583), the position depending upon the point or points where the canal terminates. Its

tissue is usually elongated into papillæ (*fig.* 582, 2), hair-like (*fig.* 584), or feathery processes (*fig.* 586), or in some cases

Fig. 585.

Fig. 586.

Fig. 587.

Fig. 585. Ventral view of a pistil of *Isopyrum biternatum*, showing the double stigma.——*Fig.* 586. Pistil of Wheat surrounded by three stamens, and two squamulæ, *s p*. Two feathery styles arise from the top of the ovary. ——*Fig.* 587. Pistil of *Dianthus Caryophyllus* on a stalk *g*, called the gynophore, below which is the peduncle. On the top of the ovary are two styles, the face of which is traversed by a continuous stigmatic surface.

it is smoother and more compact. It is never covered by true epidermis. By means of the corresponding conducting tissue of the style it is in direct continuity with the placenta. (See Stigma, page 291.) At the period of fecundation as before noticed, it becomes moistened by a viscid fluid which renders the surface more or less sticky, and thus admirably adapted to retain the pollen-grains, which are thrown upon it in various ways at the time of the dehiscence of the anther.

Fig. 588.

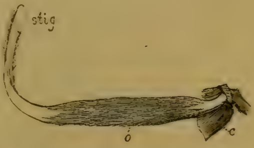


Fig. 588. Pistil of *Lathyrus*. *o*. Ovary. *c*. Persistent calyx. On the top of the ovary is the style, and stigma, *stig*.

The Gynœcium.—Having now described the parts, nature, and structure of the simple carpel, we are in a position to examine in a comprehensive manner the gynœcium or pistilline whorl generally, which is made up of one or more of such carpels.

When the gynœcium is formed of but one carpel, as in the Broom (*fig.* 568), Pea (*fig.* 588), &c., the pistil is called *simple*, and the two terms pistil and

carpel are synonymous ; when there is more than one carpel, it is called *compound* (*figs.* 587 and 566).

In a compound pistil the carpels may be either separate from each other, as in the Stonecrop (*fig.* 566), or united into one body, as in the Primrose (*fig.* 567), Carnation (*fig.* 587), and Tobacco (*fig.* 568, 2); in the former case, the pistil is said to be *apocarpous* or *dialycarpous*, in the latter *syncarpous*.

When the pistil is apocarpous, the number of carpels of which it is composed is indicated by a Greek numeral prefixed to the termination *gynia*, which means female, and the flower receives corresponding names accordingly. In a syncarpous pistil also, the number of styles is defined in a similar way. Thus :—

A flower with One carpel or One style is Monogynous, as in Myosotis, and Hippuris.
„ „ Two carpels or Two styles is Digynous, as in most British Grasses and Dianthus.
„ „ Three carpels or Three styles is Trigynous, as in Rumex and Silene.
„ „ Four carpels or Four styles is Tetragynous
„ „ Five carpels or Five styles is Pentagynous.
„ „ Six carpels or Six styles is Hexagynous.
„ „ Seven carpels or Seven styles is Heptagynous.
„ „ Eight carpels or Eight styles is Octogynous.
„ „ Nine carpels or Nine styles is Enneagynous.
„ „ Ten carpels or Ten styles is Decagynous.
„ „ Twelve carpels or Twelve styles is Dodecagynous.
„ „ More than twelve or numerous Polygynous.

These terms will be referred to again when we treat of the Linnæan System of Classification, as some of the Orders of that arrangement are determined by the number of carpels in the flower.

1. *Apocarpous Pistil.*—An apocarpous pistil may consist of two or more carpels, and they are variously arranged accordingly. Thus when there are but two, they are always placed opposite to each other; when there are more than two, and the number coincides with the sepals or petals, they are opposite or alternate with them; it is rare, however, to find the carpels corresponding in number to the sepals or petals, they are generally fewer, or more numerous. The carpels may be arranged in one whorl, as in the Flowering Rush (*fig.* 457), and Stonecrop (*Sedum*) (*fig.* 566); or in several whorls alternating with each other, either at the same level, or, as is more generally the case, at different heights upon the thalamus so as to form a spiral arrangement. When an apocarpous pistil is thus found with several rows of carpels, the receptacle or thalamus, instead of

forming a nearly flattened top as is usually the case when the number is small, frequently assumes a number of other shapes; thus, in the Magnolia and Tulip Tree, it becomes cylindrical (*fig.* 589); in the Raspberry (*fig.* 591), Ranunculus (*fig.* 530), and Adonis (*fig.* 592), conical; in the Strawberry (*fig.* 590), hemispherical; while in the Rose (*fig.* 439, *r*) the receptacle or thalamus, instead of being prolonged upwards as in the above examples, becomes hollowed out like a cup, or urn, and has the carpels arranged upon its inner surface. These modifications of the thalamus, together with some others, will be more particularly referred to under the head of the receptacle or thalamus. The varying conditions of this portion of the floral axis necessarily lead to corresponding alterations in the mutual relation of the different whorls of carpels which compose an apocarpous pistil. Thus, when there are two whorls of carpels placed upon a flattened thalamus, the inner have their ventral sutures directed towards the centre of the flower, while the outer have their ventral sutures directed to-

Fig. 589.

Fig. 589. Central part of the flower of the Tulip tree (*Liriodendron tulipifera*). The thalamus, *a*, is more or less cylindrical; *c*. Carpels; *e*, *e*. Stamens.

Fig. 590.

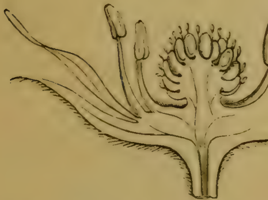


Fig. 591.

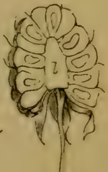


Fig. 592.

Fig. 590. Section of the flower of the Strawberry. The thalamus is nearly hemispherical, and bears a number of separate carpels on its upper portion. —— *Fig.* 591. Section of the ripe pistil of the Raspberry, showing the conical thalamus, *l*. —— *Fig.* 592. Pistil of Pheasant's Eye (*Adonis*).

wards the backs of the inner carpels; or if there are several whorls, the component carpels of each whorl are arranged in like manner with regard to those within them. When the thalamus is convex, or in any way prolonged upwards, the innermost carpels are upon a higher level than the outer; or when the thalamus is concave, the outer carpels are uppermost. These different arrangements modify very materially the appearance of the flower. The mutual relations of the component carpels,

and other matters connected with their order of development may be easily traced in apocarpous pistils, but in those cases where carpels placed under like circumstances become united and form syncarpous pistils, they give rise to very complicated structures, which will be alluded to hereafter.

2. *Syncarpous Pistil.*—Having now considered the simple carpel, and the compound apocarpous pistil, we pass to the consideration of the compound syncarpous pistil, or that in which the component carpels are more or less united. We have already seen in speaking of the floral envelopes and stamens, that the different parts of which they are respectively composed may be also distinct from each other, or more or less united. From the position of the carpels with respect to each other, and from their nature, they are more frequently united than any other parts of the flower. This union may take place either partly, or entirely, and it may commence at the summit, or at the base of the carpels. Thus in the former case, as in many Asclepiadeæ and *Xanthoxylon fraxineum* (*fig.* 593) the carpels are united by their stigmas only; in the *Dictamnus fraxinella* (*fig.* 609) the upper part of their styles are united; while in the Labiatæ (*fig.* 594) and most Boragineæ (*fig.* 595) the whole of the styles are united. In all the above cases the ovaries are distinct. These examples are to be considered, therefore, as transitional states between apocarpous and syncarpous pistils.

It is far more common to find the carpels united by their lower portions or ovaries, and this union may also take place to various extents. Thus, in the Rue (*fig.* 596) the union only takes place by the bases of the ovaries, the upper parts

Fig. 593.

Fig. 594.

Fig. 595.

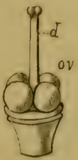


Fig. 596.

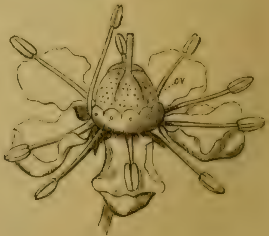


Fig. 593. Pistil of *Xanthoxylon fraxineum* supported on a gynophore, *g*. The ovaries, *o*, and styles are distinct, but the stigmas, *s*, are united.——*Fig.* 594. Pistil of Horehound (*Marrubium vulgare*), a Labiate plant. Its ovaries, *ov*, are distinct, the styles, *s*, being united.——*Fig.* 595. Pistil of *Myosotis*, a Boragineous Plant. *ov*. distinct ovaries; *d*. styles united.——*Fig.* 596. Flower of Rue (*Ruta graveolens*), showing the ovaries, *ov*, united by their bases.

remaining distinct, in which case the ovary is commonly described as lobed. In the Dianthus (*fig.* 587) the ovaries are completely united, while the styles are distinct; while in the Primrose (*fig.* 567), the ovaries, styles, and stigmas are all united. When two or more ovaries are thus completely united so as to form one body, the organ thus resulting from their union is called a *compound ovary*.

When a number of carpels are thus completely united so as to form a compound ovary, the compound body formed, may either have as many cavities separated by partitions as there are component carpels, or it may only have one. These differences have an important influence upon the attachment of the ovules, as will be afterwards seen when speaking of placentation. It will be necessary for us therefore, to explain at once the causes which lead to these differences. Thus suppose we have three carpels placed side by side (*fig.* 597, *a*); each of these possesses a single cavity, so that if we were to make a transverse section of the whole (*fig.* 597, *b*), we should necessarily have three cavities, each of which would be separated from those adjoining by two walls, one being formed by the side of its own carpel, and the other by that of the one next to it; now, if these three carpels, instead of being distinct, were united by their ovaries (*fig.* 598, *a*), so as to form a compound ovary, the latter must necessarily also have as many cavities as there are component carpels (*fig.* 598, *b*), and each cavity would be separated from those adjoining by a wall which is called a *dissepiment* or partition. Each dissepiment must be also composed of the united sides of the two adjoining carpels, and is consequently double, one half being formed by one of the sides of its own carpel, the other by that of the adjoining carpel.

Fig. 597. *Fig.* 598.

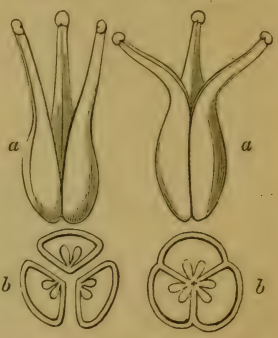


Fig. 597. *a.* Diagram of three carpels placed side by side but not united. *b.* A transverse section of the ovaries of the same. —— *Fig.* 598. *a.* Diagram of three carpels united by their ovaries, the styles being free. *b.* A transverse section of the ovaries of the same.

In the normal arrangement of the parts of the ovary, it must necessarily happen, that the styles (when they are distinct) must alternate with the dissepiments, for as the former are prolongations of the apices of the carpellary leaves, while

the latter are formed by the union of their sides, the dissepiments must have the same relation to the styles, as the sides of the blade of a leaf have to its apex, that is, they must be placed right and left of them, or alternate.

The cavities thus formed, are called *cells* or *loculi*, and such an ovary would be termed *three-celled* or *trilocular*, or if formed of two, four, five or many carpels, it would be described respectively, as two-celled or *bilocular*, four-celled or *quadrilocular*, five-celled or *quinquelocular*, and many-celled or *multilocular*. As all dissepiments are spurious or false which are not formed by the united walls of adjoining carpels, it must necessarily follow that a simple carpel can have no true dissepiment, and is hence, under ordinary and normal circumstances, unilocular.

From the preceding observations it must also follow, that when carpels which are placed side by side cohere and form a compound ovary, the dissepiments must be vertical, and equal in number to the carpels out of which that ovary is formed. When a compound ovary is composed, however, of several whorls of carpels placed in succession one over the other, as in the Pomegranate, horizontal true dissepiments may be formed by the carpels of one whorl uniting by their bases to the apices of those placed below them.

We have just observed that all dissepiments are said to be spurious except those which are formed by the union of the sides of contiguous carpels, and it occasionally happens that such dissepiments are formed in the course of growth, by which the ovary acquires an irregular character. These false dissepiments commonly arise from projections of the placentas inwards, or by a corresponding growth from some other part of the walls of the ovaries. Some are horizontal, and are called *phragmata*, as in the *Cassia Fistula* (*fig.* 599), where the ovary after fertilization, is divided by a number of transverse partitions which are projections from its walls; others are vertical, as in Cruciferous Plants, where the partition called a replum (*fig.* 600, *cl*), is formed from the placentas; also in *Datura Stramonium*, where the ovary is formed of two carpels, and is hence normally two-celled, but instead of being thus bilocular, it is quadrilocular below (*fig.* 601) from the formation of a spurious vertical dissepiment, but towards the apex it is still bilocular (*fig.* 602), the dissepiment not being complete throughout, and thus the true structure of the ovary is there indicated. In the Gourd tribe also, spurious dissepiments appear to be formed in a vertical direction by projections from the placentas. In the Flax, again (*fig.* 603, *b*), spurious incomplete vertical dissepiments are formed by projections from the dorsal sutures. In the *Astragalus* (*fig.* 604), a spurious dissepiment is also formed by a folding inwards of the dorsal suture, while in *Oxytropis* and *Phaca* (*fig.* 605) a spurious incomplete dissepiment is produced by a folding inwards of the ventral suture. Various other examples

Fig. 599.

Fig. 600.

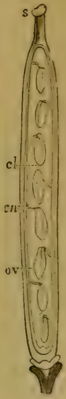


Fig. 601.

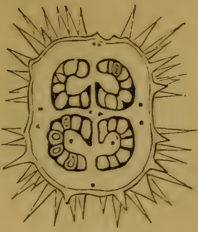


Fig. 602.

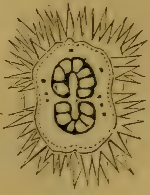


Fig. 599. A vertical section of a portion of the mature pistil of *Cathartocarpus* or *Cassia Fistula*, showing a number of transverse spurious partitions.—— *Fig.* 600. Vertical section of the pistil of the Wallflower. *s.* Style surmounted by the stigma. *ov.* Ovules attached by a stalk to the placenta, *cn.* *cl.* Vertical spurious partition called the replum. —— *Fig.* 601. Transverse section of the lower part of the ovary of the Thorn-apple (*Datura Stramonium*), showing that it is here quadrilocular. —— *Fig.* 602. Transverse section of the same ovary at its upper part, showing that it is here bilocular.

Fig. 603.

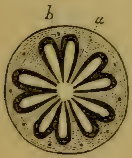


Fig. 604.

Fig. 605.

Fig. 603. Transverse section of the ovary of the Flax (*Linum*), showing five complete and true dissepiments, *a*, and five incomplete spurious dissepiments, *b.* —— *Fig.* 604. Transverse section of the pistil of *Astragalus*, showing spurious dissepiment proceeding from the dorsal suture. —— *Fig.* 605. Transverse section of the ripe pistil of *Phaca.*

of the formation of spurious dissepiments might be quoted, but the above will be sufficient for our purpose. It should be noticed that in our description of spurious dissepiments, we have not confined our attention to those of compound ovaries alone, but have also referred to those of simple ovaries, in which they may equally arise. Thus the spurious dissepiments of Cassia Fistula, Astragalus, and Oxytropis, are examples of such formations occurring in simple ovaries.

We have now to consider the formation of the compound ovary which presents but one cavity, instead of two or more,

as in that just alluded to. This is produced, either by the union of the contiguous margins of flattened carpellary leaves, as in the Mignonette (*Reseda*) (*fig.* 606), and Cactus (*fig.* 616); or by the union of carpels which are only partially folded inwards, so that all their cavities communicate in the centre, and hence such a compound ovary is really unilocular, as in the Orchis (*fig.* 607), and Poppy (*fig.* 608).

Having now described the parts, nature, and structure of the simple carpel, and of the gynœcium, we proceed in the next place to allude generally to their constituent parts; namely, the ovary, style, and stigma.

Fig. 606.

Fig. 607.

Fig. 608.

Fig. 606. Transverse section of the unilocular ovary of Mignonette (*Reseda*). *c.* Carpels of which it is formed. *pl.* Parietal placentas.—— *Fig.* 607. Transverse section of the unilocular ovary of an Orchis. *c.* Carpels, slightly infolded. *pl.* Placentas.—— *Fig.* 608. Transverse section of the ovary of a species of Poppy. *ov.* Ovules. *pl.* Placentas, which in the young ovary almost meet in the centre, and thus it becomes almost multilocular, but as the ovary progresses in development it is seen to be distinctly unilocular.

Fig. 609.

Fig. 609. Pistil of *Dictamnus Fraxinella.* The ovary is supported on a gynophore, *g*, and is superior.

1. The Ovary.—The ovary, as already defined, is called *compound* when it is composed of two or more ovaries combined together; on the contrary, it is *simple* when it constitutes the lower part of a single pistil, or of one of the carpels of an apocarpous pistil. It should be noticed, therefore, that the terms simple pistil, and simple ovary, are not in all cases synonymous terms; thus, a pistil is only said to be simple (*figs.* 568 and 588), when the gynœcium is formed of but one carpel, the two terms pistil and carpel being then mutually convertible; but an ovary is simple, as just noticed, whether it forms part of a simple pistil, or of one of the carpels of an apocarpous pistil.

Generally speaking, the ovary is *sessile* upon the receptacle or thalamus, the carpellary leaves out of which it is

formed having no stalks. In rare cases, however, the ovary is more or less elevated above the outer whorls, when it is said to be stalked or *stipitate*, as in the Passion-flower, Dictamnus (*fig.* 609, *g*), and Dianthus (*fig.* 587, *g*) ; this stalk has received the name of *gynophore*. We shall refer to it again under the head of receptacle or thalamus.

The ovary, whether simple or compound, as already noticed, (see p. 226), may be either adherent to the calyx, or free from it. In the former case, as in the Myrtle (*fig.* 448), it is *inferior* or adherent, and the calyx is *superior;* in the latter, as in the Lychnis, Barberry (*fig.* 569), and Dictamnus (*fig.* 609), it is *superior* or *free*, and the calyx is *inferior.* Sometimes the ovary is but partially adherent to the calyx, as in the Saxifrage (*fig.* 610), and other plants of the order to which that belongs, in which case it is sometimes termed *half-adherent* or *half-inferior*, the calyx being then *half-superior;* the latter terms are, however, but rarely used, the ovary being commonly described as inferior, whether its adhesion to the calyx be complete or only partially so, and *vice versâ.* The young observer must be careful not to confound the inferior ovary, as now described, with the apparently inferior ovaries of such flowers as the Rose (*fig.* 439), where the receptacle is concave and attached to the calyx, and bears a number of carpels on its inner walls : a transverse section will at once show the difference ; thus, in the Rose we should find a single cavity open at its summit, and covered with distinct carpels ; whereas, on the contrary, a true adherent ovary would show one or more loculi closed at the apex, and containing ovules. The ovaries of the Rose are therefore strictly superior or free.

Fig. 610.

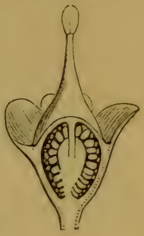


Fig. 610. Vertical section of the flower of a Saxifrage, showing the ovary partially adherent to the calyx.

Schleiden contends that the ovary is not always formed of carpels, but sometimes also of the stem, and at other times of the two combined. His views are not generally received by botanists, and we need not therefore further allude to them. It is probable however, that the thalamus by becoming hollowed out may in some cases form part of the ovary, in the same manner as it occasionally under similar circumstances forms a part of the calyx, as already noticed in *Eschscholtzia.*

The ovary varies in form and appearance ; when *simple*, it is generally more or less irregular, but when *compound*, it is commonly regular. Exceptions to the regularity of compound ovaries may be seen in the *Antirrhinum* (*fig.* 611), and in other instances. In form, the compound ovary is generally more or less spheroidal, or ovate. The outer surface may

Fig. 611.

Fig. 611. Compound irregular ovary of *Antirrhinum*.

be either perfectly even or uniform, thus showing no trace of its internal divisions ; or it may be marked by furrows extending from its base to the origin of the style, and corresponding to the points of union of its constituent carpels. When these furrows are deep, the ovary assumes a lobed appearance, and is described as one, two, three, four, five, or many lobed, according to circumstances. Sometimes we find, in addition to the furrows which correspond to the dissepiments or points of union of the carpels, others of a more superficial character which correspond to the dorsal sutures. At the latter points, however, it is more common to find slight projections, which then give a somewhat angular appearance to the ovary.

The epidermis covering the surface of the ovary, may be either perfectly smooth, or covered in various ways with different kinds of hairs, or prickles ; or it may assume a glandular appearance ; in which cases the same terms are used as in describing similar conditions of the surface of the leaves, or other organs of the plant.

Fig. 612.

Fig. 612. Pistillate flower of a species of *Euphorbium*, with three divided styles.

When the ovary is compound, the number of carpels of which it is composed may be ascertained in one or more of the following ways. Thus, when the styles or stigmas remain distinct, the number of these generally corresponds to the number of carpels. It does, however, occasionally happen, as in the Euphorbia (*fig.* 612), that the styles are themselves divided, in which case they would of course indicate a greater number of carpels than are actually present ; we must then resort to other modes of ascertaining this point, such, for instance, as the furrows, or lobes on the external surface of the ovary, or the number of partitions or loculi which it contains, as these commonly correspond in number to the carpels of which that ovary is composed. The mode of venation may in some cases also, form a guide in the determination; while in others, the manner in which the ovules are attached must be taken into consideration. We will now pass to the examination of the latter point.

Placentation.—The term *placenta* is by most botanists applied to the more or less marked projection occurring in the cavity of the ovary to which the ovules are attached ; by others, it is restricted to the point corresponding to the attachment of each ovule, and the term *placentaries* is then given to the projecting

line or ridge which is formed by the union of several placentas. These placentas are variously distributed in different plants, but their arrangement is always the same for any particular one, whence their accurate discrimination is of very great importance. The term *placentation* is used to indicate the manner in which the placentas are distributed. The placenta is called by Schleiden the *spermophore.*

In describing this subject, we shall first allude to the different kinds of placentation, and then proceed to explain the views generally entertained as to their origin.

1. *Kinds of Placentation.*—In the simple ovary, the placenta is situated at the ventral suture or that point which corresponds to the union of the two margins of the carpellary leaf (*fig.* 613); such a placenta is therefore termed *marginal*, or *axile* from its being turned towards the axis of the plant.

Fig. 613.

Fig. 613. Vertical section of the flower of the Stonecrop. *pl.* Placenta of one of the carpels arising from the ventral suture.

In compound ovaries we have three different kinds of placentation; namely, *axile*, *parietal*, and *free central.* The *axile* occurs in all compound many-celled ovaries, because in these each of the component carpels is placed in a similar position to the simple ovary, and hence the placentas situated at their ventral sutures will be arranged in the centre or axis, as in the Lily (*fig.* 614), and Campanula (*fig.* 615). By many botanists this mode of

Fig. 614.

Fig. 615.

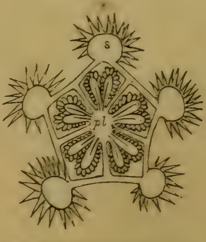


Fig. 616.

Fig. 614. Transverse section of the compound ovary of the Lily. The ovary is trilocular. The placentas, *pl*, are axile.——*Fig.* 615. Transverse section of the ovary of Campanula. The ovary is five-celled, and the placentation *pl*, axile.——*Fig.* 616. Transverse section of the ovary of a Cactus. The ovary is unilocular and the placentation parietal.

placentation is called *central*, and the term *axile* is restricted to the form of placentation where the placenta is supposed to be a prolongation of the axis. This will be afterwards alluded to.

In a compound one-celled ovary there are two forms of placentation, namely, the parietal, and the free central. It is termed parietal, when the ovules are attached to placentas either placed directly on the wall of the ovary, as in Reseda (*fig.* 606), and Cactus (*fig.* 616), or upon incomplete dissepiments formed (as already noticed) by the partially infolded carpels, as in the Orchis (*fig.* 607) and Poppy (*fig.* 608). In parietal placentation, the number of placentas corresponds to the number of carpels of which the ovary is formed. When the placentas are not attached to the walls of the ovary, but are situated in the centre of the cavity and perfectly unconnected with those walls, they form what is called a *free central placenta*, as in the Caryophyllaceæ (*figs.* 618 and 619), Primulaceæ (*fig.* 620), &c.

Fig. 617.

Fig. 618.

Fig. 619.

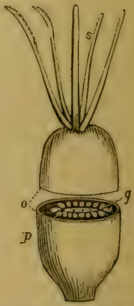


Fig. 617. Transverse section of the young ovary of Lychnis, showing five partitions proceeding from the walls of the ovary to the placentas in the centre; these partitions are destroyed by the growth of the ovary, so that the placentation is ultimately free. —— *Fig.* 618. Vertical section of the *Cerastium hirsutum* (*Caryophyllaceæ*), *o*. Ovary. *p*. Free central placenta. *g*. Ovules. *s*. Styles. —— *Fig.* 619. Transverse section of the same with the two portions separated. *o*. Ovary. *p*. Placenta. *g*. Ovules. *s*. Styles. From Jussieu.

Besides the regular kinds of placentation just described, it sometimes happens that the ovules are placed more or less irregularly in the cavity of the ovary. Thus, in the Flowering Rush (*Butomus*) (*fig.* 621) they cover the whole inner surface of the carpels; in the *Nymphæa*, they are attached all over the dissepiments; in *Cabomba*, they arise from the dorsal suture; and in Broomrape (*Orobanche*), from placentas placed within the margins of the ventral suture.

2. *Origin of the Placenta.*—Having now described the different kinds of placentation, we proceed to consider the views entertained as to their origin. It is generally believed that the

Fig. 620.

Fig. 621.

Fig. 620. Vertical section of the pistil of Cyclamen (*Primulaceæ*). *s.* Sepals. *pl.* Free central placenta. *st.* Style. *stig.* Stigma.——*Fig.* 621. Vertical section of the flower of the Flowering Rush, showing the inner surface of the carpels covered all over with ovules.

placenta is, in most cases at least, a cellular growth developed from the confluent margins of the carpels, and bearing ovules upon its surface. In some cases the placenta extends along the whole line of union of the carpel, or it may be confined to its base or apex. Each placenta is therefore to be considered as composed of two halves, one half being formed by each margin of the carpel. Thus in simple ovaries, the placenta is developed by a single carpel; in compound many-celled ovaries, the placentas are in like manner formed from the contiguous margins of each individual carpel of which it is composed; while in compound one-celled ovaries presenting parietal placentation, each placenta is formed from the contiguous margins of two carpels, and is hence produced by two adjoining carpels. Before proceeding to describe the nature of the free central placenta, it will be necessary to conclude our notice of the above forms, as its description involves the discussion of a different view of the origin of the placenta.

That the placentas are really developed in the above forms of placentation from the margins of the carpels seems to be proved in various ways. Thus in the first place, the placentas always correspond to the points of union of the margins of the carpel, and hence would naturally be considered as formed from them; and secondly, we frequently find, that in monstrosities or abnormal growths where the carpel is developed in a more or less flattened condition, that a placenta bearing ovules is formed upon each of its margins. The production of the ovules in these cases may be considered as analogous to the formation of buds on the margins of leaves, as in *Bryophyllum calycinum* (*fig.* 195), already referred to. The formation of the placentas

from the margins of the carpels in axile and parietal placentation, may be considered, therefore, as capable of being proved by direct observation, and from analogy to what occurs in certain ordinary leaves.

We now pass to consider the origin of the free central placenta. The theory formerly entertained was, that this also was a development from the margins of the carpels. It was thought that the carpels of which the compound ovary was formed, originally met in the centre and developed placentas from their margins in the same manner as in ordinary axile placentation, but that subsequently the walls of the ovary grew more rapidly than the dissepiments, so that the connexion between them was soon destroyed ; and that from this cause, and also from the great subsequent development of the placenta, the septa ultimately became almost or quite broken up, so that it was left free in the cavity of the ovary. This theory is strengthened by the fact, that in several of the Caryophylleæ, we often find traces of dissepiments at the lower part of the ovary (*fig.* 617), whence it may be concluded, that these are the remains of dissepiments which become ruptured on account of the unequal development of the parts of the ovary. In the Primrose, however, and many other plants, which have a free central placenta, — no traces of dissepiments can be found at any period of the growth of the ovary. Duchartre, and others also, who have traced the development of the ovary in the Primulaceæ, state, that the placenta is free in the centre from its earliest appearance; that it is originally a little papilla on the apex of the thalamus, and that the walls of the future ovary grow up perfectly free, and ultimately enclose it. The formation of such a free central placenta cannot be well explained upon the marginal theory, as the carpels have never had any connexion with it except at their base. Hence this kind of placentation has been supposed by Schleiden, Endlicher, and many other botanists, not to be formed from the carpels at all, but to be a prolongation of the axis, which bears ovules, instead of buds as is the case with branches generally. This theory explains very readily the formation of the free central placenta of *Primula*, and hence such a placenta has been denominated *axile* by some botanists ; but as this name had been previously applied to another form, the adoption of such a term cannot but lead to much confusion. The free central placenta of *Primula* can only be explained on the marginal or carpellary theory of the formation of placentas, by supposing, either that the placentas are only produced at the base of the carpels, and subsequently elongate and enlarge, or that they are formed by a whorl of placentas developed separately from the carpels by a process of chorisis, and that these afterwards become united in the centre of the ovary.

Schleiden, indeed, and some other botanists regard the placenta in all cases as a development from the axis of the plant. Schleiden, particularly, has written an elaborate paper in support of this view. The axile and free central placentation are readily to be explained by it, but the formation of the parietal placenta is by no means so clear. It is supposed that the axis ramifies in the cavity of the ovary, and that the branches curve directly from their origin towards the side, and become blended with the margins of the two carpels on their inner side, and form parietal placentas bearing the ovules as lateral buds. Schleiden thinks, that the formation of the ovule in the Yew, where it terminates a branch, and is naked, is incompatible with the marginal theory. He thinks, also, that the formation of the ovules generally in the Coniferæ, support his views of placentation. He regards the ovules in those plants as being given off from the axis of the cone, which he calls a placenta, and the scales, or bracts, which are situated between them, he believes to be open carpellary leaves. Schleiden also states, that no satisfactory explanation can be given by the advocates of the marginal theory of placentation, of the formation of the ovule and placenta in *Armeria*, in which the ovary composed of five carpels surrounds a single ovule, which rises from the bottom of the axis, supported on a stalk which curves downwards at its apex, and thus suspends the ovule free in the centre of the cavity (*fig.* 622). He accordingly concludes, that the ovule and placenta are developments of the axis. Many other arguments in favour of the universal applicability of the axial theory in the formation of the placenta have been brought forward by Schleiden, and others, but their further discussion would be out of place here. For additional particulars, I must refer the reader to *Schleiden's Principles of Botany, translated by Lankester*, and to *Lindley's Introduction to Botany*.

Fig. 622.

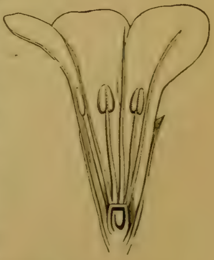


Fig. 622. Vertical section of the flower of *Armeria*. The ovary is seen to contain but a single ovule suspended from a funiculus. The ovule is said to be reclinate.

From all that has been stated, we may perhaps be allowed to draw the following conclusions, namely :— that no one theory sufficiently accounts for the production of the placenta in all cases ; but that the axile and some forms of the free central placentation may be explained on both hypotheses ; that the parietal placentation is best explained upon the marginal theory ; and that the formation of the free central placenta of the Primulaceæ, Santalaceæ, &c., can only be

satisfactorily explained by considering the placenta as a production of the axis.

In a practical point of view, the mode of production of the placenta is of little importance. The accurate discrimination of the different kinds is however of much value in descriptive botany, by affording us constant, and hence important characters, for distinguishing plants. Some natural orders exhibit more than one kind of placentation, and hence cannot be distinguished by any particular one ; in such orders, therefore, the placentation can only be applied in obtaining good characteristics of certain genera. In the majority of instances, however, we find one kind of placentation occurring throughout all the plants of a particular natural order. Thus, the Scrophulariaceæ, Ericaceæ, Campanulaceæ, &c., present us with axile placentation ; the Papaveraceæ, Violaceæ, Grossulariaceæ, Orobanchaceæ, Cruciferæ, &c., with parietal ; and the Caryophyllaceæ, Santalaceæ, Primulaceæ, &c., with free central.

2. The Style.—We have already described the general nature and structure of the style in speaking of the carpel. There are certain other matters connected with it still to be alluded to.

The style generally arises from the geometrical summit of the ovary, of which it is a continuation in an upward direction, as in the Primrose (*fig.* 567), it is then termed *apicilar* or *apical*. In other cases, the apex of the ovary becomes inflected towards the side or base, from the carpel or carpels of which it is formed being folded like ordinary leaves in reclinate vernation, the style then becomes *lateral*, as in the Strawberry (*fig.* 623), or *basilar*, as in the Alchemilla (*fig.* 624). In the two latter

Fig. 623.

Fig. 624.

Fig. 625.

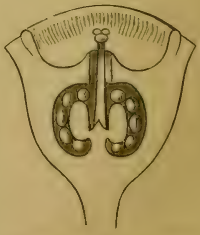


Fig. 623. One of the carpels of the Strawberry with a lateral style. —— *Fig.* 624. Carpel of *Alchemilla* with a basilar style. The stigma is capitate. —— *Fig.* 625. Vertical section of the ovary of *Babingtonia*. From Lindley.

cases therefore, the geometrical and organic apices of the ovary do not correspond, as the point of origin of the style always determines the latter.

The style is generally directly continuous with the ovary, which gradually tapers upwards to it, as in *Digitalis*, in which case it is more or less *persistent*, and then it sometimes forms a part of the fruit; at other times, however, there is a kind of contraction or species of articulation at the point where the style springs from the ovary, as in *Scirpus*, and then the style always falls off after the process of fertilization is completed, in which case it is said to be *deciduous*.

While the style is to be regarded as being formed, in by far the majority of cases by a prolongation of the apex of the carpellary leaf, it seems probable that in some cases, it is a mere process of the placenta. Thus in the *Babingtonia*, as shown by Lindley (*fig.* 625), " the style is a direct extension of the placenta, and does not even touch the carpels, but is protruded through a hole in the vertex of the ovary."

When the style is basilar or lateral, and the ovary to which it is attached more or less imbedded in the receptacle or thalamus, it frequently appears to spring from the latter part; such an arrangement is called a *gynobase*, and the ovary is said to be *gynobasic*. In the Labiatæ (*fig.* 594), and Boragineæ (*fig.* 595), the four ovaries are free, but the styles become connected and form a central column, which appears therefore to be a prolongation of the thalamus.

Fig. 626.

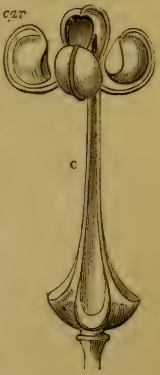


Fig. 626. The carpophore c, of a Geranium, with the rolled back carpels, *car.*

Such an arrangement must not be confounded with that of the ovaries and styles of the *Geranium* (*fig.* 626). and some other plants, where the axis is prolonged in the form of a beak-like process, to which the ovaries and styles become united, and from which they separate when the fruit is ripe. This prolongation of the receptacle or thalamus is termed a *carpophore*, or by some botanists a *gynophore*, but the latter term is properly applied, as already noticed, to the stalk which occasionally supports the ovary, as in the Passion-flower, Dianthus, &c. (See page 281.)

We have already stated that when the styles of a syncarpous pistil are distinct, that they usually correspond to the number of carpels of which that pistil is composed. It sometimes happens, however, that the style of each carpel bifurcates or becomes forked, as in some Euphorbiaceæ, either once (*figs.* 612 and 628), or twice (*fig.* 627); so that the number of the styles above, is then double or quadruple that of the carpels. When two or more styles are united into one body, this is termed a *compound*

Fig. 627.

Fig. 628.

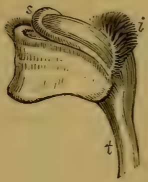
Fig. 627. Female flower of one of the *Euphorbiaceæ*, c. Calyx. *p*, *p*. Petals. *t*. Membranous expansion round the ovary. *o*. Ovary, with three styles, *s*, each of which is twice forked.——*Fig.* 628. Ovary of Castor Oil Plant, (*Ricinus communis*). The styles in this case are once forked.

style. This adhesion may take place either entirely, as in the Primrose (*fig.* 567), when the style is improperly termed *simple*, (undivided or entire would be a better term); or the union is more or less incomplete as we proceed towards its apex, and corresponding terms are used accordingly; these are similar to those previously mentioned in describing the degree of division of the other parts of the plant. Thus it is said to be cleft, when the union between the component styles extends to at least mid-way between their base and apex, and the style is said to be *bifid*, *trifid*, *quadrifid*, *quinquefid*, or *multifid*, according as it is two, three, four, five, or many-cleft. If the union between the component styles does not extend to midway between their base and apex, the style is *partite*, and is described as *bipartite*, *tripartite*, *quadripartite*, &c., according to the number of partitions.

Form and Surface.—In form the style is generally more or less cylindrical; and either tapering from the base to the apex, as is more frequently the case, or becoming enlarged as it proceeds upwards. At other times the style is filiform, or more or less thickened, or angular; and rarely thin, coloured, and flattened like a petal, as in Canna, and Iris (*fig.* 629): it is then said to be *petaloid.*

The surface of the style may be either smooth, or covered in various ways with glands and hairs. These hairs when situated on the style, frequently serve the purpose of collecting the pollen as it is discharged from the anther, and are hence termed

Fig. 629. *Fig.* 630. *Fig.* 631.



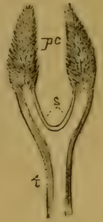


Fig. 629. Pistil of Iris. *o.* Ovary. *sty.* Petaloid styles. *stig.* Stigmas.——*Fig.* 630. Upper part of the style and stigma of *Leschenaultia formosa.* *t.* Style. *s.* Stigma. *i.* Indusium.——*Fig.* 631. Upper part of the style, *t*, of a Composite Plant dividing into two branches, which are covered above by collecting hairs, *pc.* *s.* True stigma.

collecting hairs. The collecting hairs on the style of the Campanula (*figs.* 117 and 118) are retractile; they have been already described under the head of hairs. (See p. 49.) In the Compositæ, the surface of the style is more or less covered with stiff collecting hairs (*fig.* 631, *pc*), and as this organ is developed later than the stamens, it is at first shorter than they are, but as growth proceeds, it breaks through the adhering anthers, and thus the hairs on its surface come in contact with the pollen and become covered with it. In allied orders to the Compositæ, namely, the Goodeniaceæ (*fig.* 630, *i*) and the Lobeliaceæ, the hairs form a little ring below the stigma, to which the term of *indusium* has been given.

3. The Stigma.—The stigma has been already described as being connected with the placenta by means of the conducting tissue of the style; hence it may be considered as a portion of the placenta prolonged upwards, but differing from it in not bearing ovules. If this be the proper view of the structure of the stigma, this part like the placenta must be regarded as double, one half being formed by each margin of the carpellary leaf, and hence each simple pistil or carpel has necessarily two stigmas, the normal positions of which are lateral. That eminent botanist Dr. Robert Brown, alludes to this subject in the following manner:—"That the stigma is always lateral may be inferred from its being obviously so in many cases; and in one genus at least, *Tasmannia*, it extends nearly the whole length of the ovarium, so as to be commensurate with and placed exactly opposite to the internal polyspermous placenta.

"That the stigma is always double appears probable, from those cases in which it is either completely developed, as in the greater part of Gramineæ, where the ovarium is simple; in the compound ovarium in *Urena;* and from those in which the development, though less complete, is still sufficiently obvious, as in many Euphorbiaceæ and in several Irideæ. This degree of development, however, is comparatively rare, confluence between the two stigmata of each carpel being the more usual structure; and in the compound pistillum a greater degree of confluence often takes place in the stigmata than in the placentæ, —a fact which in all such cases is obviously connected with adaptation of surface to the more complete performance of function." In many Rosaceæ, as in the Rose, &c., the stigma is notched on the side corresponding to that from which the placenta arises, which is another proof of its double nature.

The stigmas of a syncarpous pistil are generally opposite to the cells, and alternate with the dissepiments, but it sometimes happens, as in the Poppy (*fig.* 428), that half the stigma of one carpel unites with a similar half of the adjoining carpel, and thus it becomes alternate with the cells, and opposite to the dissepiments.

The term stigma is only properly applied to that portion of the style which is destitute of epidermis and which secretes the stigmatic fluid; but it is often improperly given to more divisions of the style. Thus in the Iris (*fig.* 629), the three petaloid portions of the style are by some botanists termed petaloid stigmas; whereas the stigma is properly confined to a little transverse space near the apex of each division. In many plants of the natural order Leguminosæ, such as *Lathyrus* (*fig.* 588), *Vicia*, &c., the hairy part towards the summit of the style has been termed a stigma, but the latter is confined to the apex of that organ. In Labiate Plants also, the style frequently divides above into two branches (*fig.* 594), and these have been called stigmas, but the latter, as in the instances just alluded to, are confined to the apices of the divided portions of the style.

We have already seen that the stigma may be separated from the ovary by the style, or the latter organ may be absent, in which case it is said to be *sessile*, as in the Barberry (*fig.* 569), Poppy (*fig.* 428), Vine (*fig.* 506), &c. In Orchids the stigma is sessile on the gynostemium (*figs.* 534 and 552), and appears as a little cup-shaped viscid space just below the attachment of the pollen masses.

In a syncarpous pistil the stigmas may be either united together, as in the Primrose (*fig.* 567), or distinct, as in *Linum* (*fig.* 632), and *Campanula* (*fig.* 492); in the latter case, instead of looking upon these separate parts as so many distinct stigmas, it is usual to describe them as if they were portions of

but one; thus we speak of a *bifid*, *trifid*, &c., stigma, or a *bilobate*, *trilobate*, &c., stigma, according to the number and appearance of the divisions. The term lobe is usually applied when the divisions are thick, as in the Lily (*fig.* 633), and Melon (*fig.* 634); or when these are flattened and somewhat strap-shaped, as in the Compositæ (*fig.* 634, 2), the stigma

Fig. 632.

Fig. 633.

Fig. 634.

Fig. 634, 2.

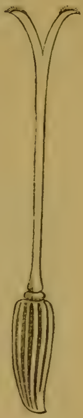


Fig. 632. Pistil of Flax (*Linum*). ——*Fig.* 633. Pistil of Lily, with one style and a trilobate stigma.—— *Fig.* 634. Lobed stigma of Melon.——*Fig.* 634, 2. Pistil of Chrysanthemum, with one style and a two-lobed stigma, the lobes with hairs at their extremities.

is fissured or cleft; or when flattened into plates or bands they are lamellæ, as in the *Bignonia* (*fig.* 635) and *Mimulus*. The number of these divisions in the majority of instances, corresponds to the number of carpels of which the pistil is composed; and if the latter organ is many-celled, the number of cells will generally correspond also, to the divisions of the stigma. Thus the five-cleft stigma of some Campanulas, indicates that there are five cells to the ovary, and that the pistil is formed of five carpels. In the Gramineæ (*fig.* 586) and Compositæ (*figs.* 631 and 634, 2), however, we have a bifid stigma, and but one loculus or cell in the ovary; this probably arises from the non-development or abortion in the ovary of one of the carpels.

The lobes assume different appearances: thus, they may be smooth, or thick and fleshy, as in the Melon (*fig.* 634); or feathery, as in many Grasses (*fig.* 586), or fringed or laciniate, as in *Crocus*, and *Rumex* (*fig.* 636), &c.

When the stigmas are united, the number of parts in the compound stigma is usually indicated by radiating furrows, or grooves. When the stigmas unite and form a compound body

Fig. 635. *Fig.* 636.

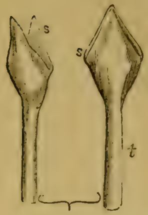
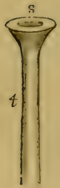


Fig. 635. Stigma, *s*, attached to style, *t*, of *Bignonia arborea*. In the left hand figure the *lamellæ* are separate, in the other applied closely to one another.——*Fig.* 636. Flower of a species of *Rumex*, showing fringed stigmas, *pl*.

upon the top of the style, which is larger than it, this compound stigma or head is said to be *capitate*; and this head may be either globular, as in *Daphne* (*fig.* 638), or hemispherical, as in the Primrose (*figs.* 531 and 567), or polyhedral, or club-shaped, or peltate or shield-shape, as in the *Arbutus* (*fig.* 637), and Poppy (*fig.* 428), &c. In the Violet (*fig.* 639), the stigma presents an irregular hooded appearance.

Fig. 637. *Fig.* 638. *Fig.* 639.



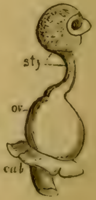


Fig. 637. *s*. Peltate stigma surmounting the style, *t*, of a species of *Arbutus*.——*Fig.* 638. Pistil of *Daphne*. *o*. Ovary. *st*. Style. *stig*. Stigma.——*Fig.* 639. Pistil of Pansy (*Viola tricolor*). *o*. Ovary. *sty*. Style surmounted by an irregular hooded stigma.

4. The Receptacle, Thalamus, or Torus.

The apex of the peduncle, or the summit of the axis, upon which the different whorls of the flower are arranged, has been called by botanists the *receptacle*, *thalamus*, or *torus*. The use of these terms indifferently has often led to much confusion, in consequence of two of them being also sometimes applied in a different sense. Thus that of receptacle is used in a

special manner (as already mentioned under the head of the Peduncle) (see page 194), to indicate this body, when it is shortened and dilated in a more or less horizontal manner, and bears a number of flowers; while the term torus is also used by some botanists, as synonymous with disk. (See page 265.) To prevent confusion, therefore, it would be far better to apply the term thalamus alone, to the apex of the peduncle or floral axis upon which the different whorls of a solitary flower are arranged. This term has been therefore chiefly used in this volume.

In the majority of plants, the thalamus is a little flattened surface or point, and accordingly presents nothing remarkable; in other plants, however, it becomes much enlarged, and then assumes a variety of appearances, and thus modifies to a considerable extent the form of the flower. Most of these forms have been already referred to when describing the pistil, but it will be more convenient for reference, &c., if we now speak of all the essential modifications. In the Magnolia, Tulip Tree, and plants of the order Magnoliaceæ generally, the thalamus is cylindrical (*fig.* 589); in the Pine-apple also (*fig.* 706, 2), and plants of the order Anonaceæ generally, it acquires a somewhat similar form; in the Raspberry (*fig.* 591), Ranunculus (*fig.* 530), and Adonis (*fig.* 592), it is conical; in the Strawberry (*fig.* 590), it is hemispherical; in *Nelumbium* (*fig.* 640), it is a large tabular expansion, in which there are a number of cavities containing the ovaries. In the Rose, it forms a concavity upon which the carpels are placed (*fig.* 439).

Fig. 640.

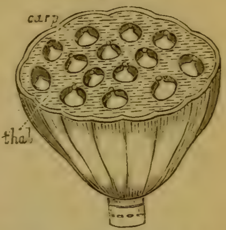


Fig. 640. *Thal.* Thalamus of Nelumbium. *carp.* Carpels.

In the Primulaceæ, Santalaceæ, and in all cases where the placenta is free from the walls of the ovary from its earliest appearance, the thalamus becomes prolonged into the cavity of the ovary and forms the placenta. At other times the thalamus becomes prolonged beyond the ovary, as in the Geraniaceæ, Umbelliferæ, &c.; this prolongation is termed a *carpophore.* In the Geranium (*fig.* 626), this carpophore forms a long beak-like process, to which the styles are attached, and which only separate when the fruit is ripe. In some cultivated flowers, as in the Rose, the thalamus will frequently acquire a monstrous development, and become extended into a branch bearing true leaves instead of carpels (*fig.* 641).

In some plants the thalamus becomes prolonged beyond the calyx and forms a stalk to the ovary, to which the term of *gynophore* has been applied. (See p. 281.) This may be seen in

some of the Capparidaceæ (*fig.* 642); in the Passion-flower, in the Pink (*fig.* 587, *g*), *Dictamnus* (*fig.* 609), *Xanthoxylon* (*fig.* 593), &c. This prolongation or stalk of the ovary is by some considered to be formed by the union of the petioles of the carpellary leaves of which that ovary is composed.

Fig. 641.

Fig. 642.

Fig. 641. Monstrous development of the Flower of the Rose, showing the thalamus prolonged into a branch which bears true leaves instead of carpels.——*Fig.* 642. Flower of a species of *Gynandropsis*, belonging to the Capparidaceæ. *cal.* Calyx. *cor.* Corolla. *st.* Stamens. *thal.* Prolonged thalamus or gynophore, supporting the ovary, *ov.*

Section 5.—The Fruit.

We have already seen that the ovary has in its interior one or more little oval or roundish bodies, called ovules or rudimentary seeds; their description therefore, in a regular arrangement, should follow that of the ovary. It is however, far more convenient to examine in the first place, the structure and general characters of the fruit, as this is composed essentially of the ripened ovary, and its description comes therefore naturally at the present time, when the details connected with that organ

are fresh in our memories. Such an arrangement has, also, the further advantage of enabling us to describe the seed immediately after the ovule, as these two organs are, in like manner, only different conditions of one body.

Nature of the Fruit.—After the process of fertilization has been effected, important changes take place in the pistil and surrounding organs of the flower, the result of which is the formation of the fruit. The fruit consists essentially of the mature ovary or pistil, containing the ripened ovules or seeds. Although the fruit may thus be described as consisting essentially of the mature pistil, other parts of the flower are also frequently present, and assist in its composition. Thus in those cases where the calyx is adherent to the ovary, as in the Apple, Pear, Melon, Gooseberry, &c., that organ necessarily forms a part of the fruit; in the Rose the concave thalamus, which bears the carpels on its inner surface, becomes a portion of the fruit; in the Strawberry, again, the fruit consists of the succulent hemispherical thalamus, bearing the carpels on its convex surface; in the Acorn, Hazel-nut, Filbert, &c., it consists of pistil, calyx, and bracts, combined together; while in the Pineapple (*fig.* 706, 2), it is composed of the ovaries, floral envelopes, and bracts of several flowers; in the Fig also (*fig.* 383), we have a fruit formed of a number of separate flowers enclosed in a fleshy receptacle. These examples, and a number of others might have been alluded to, will show, that although the fruit consists essentially of the ovary enclosing the ripe seeds, yet the term is also applied to whatever is combined with it, so as to form a covering to the seeds.

Changes produced in the Ovary in the course of its Development.—The fruit being essentially the ovary in a mature state, it should correspond with it in structure. This is the case generally, and we find the fruit therefore consisting of the same parts or organs as the ovary, only in a modified condition; thus, the walls of the ovary commonly alter in texture, and either become dry, membranous, coriaceous, woody, &c.; or, on the contrary, more or less pulpy, fleshy, &c.

At other times more important changes take place during the ripening of the ovary, which disguise the real structure of the fruit. These changes, either arise from the addition, or abortion, or obliteration of parts. Thus, 1st. The addition of parts is commonly produced by the formation of the spurious dissepiments already alluded to. In the *Datura Stramonium*, for instance, we have a two-celled ovary converted into an imperfectly four-celled fruit, by the formation of a spurious vertical dissepiment (*figs.* 601 and 602); this dissepiment appears to be formed by the projection of the placentas on the two sides, which meet, and become united to corresponding projections from the dorsal sutures. In the *Cassia Fistula*, again (*fig.* 599), and some other fruits

of a similar nature, we have a one-celled ovary converted into a many-celled fruit, by the formation of a number of transverse dissepiments. In the *Pretrea zanguebarica*, a one-celled ovary is converted into a six-celled fruit (*fig.* 642, 2), by an extension and doubling inwards of the placenta. In *Tribulus terrestris*, the ovary is quinquelocular, but as it approaches to maturity, each loculus (*figs.* 643 and 644) becomes divided into as many divi-

Fig. 642, 2.

Fig. 644. *Fig.* 643.

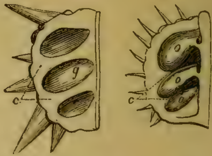


Fig. 642, 2. Transverse section of the fruit of *Pretrea zanguebarica*. From Lindley.——*Fig.* 643. A vertical section of a loculus of the ovary of *Tribulus terrestris*. *o, o, o*. Ovules. *c*. Projections from the wall which are commencing to separate the ovules.——*Fig.* 644. A vertical section of the loculus of a ripe ovary of the same, in which the partitions, *c*, completely separate the seeds, *g*.

sions as there are seeds contained within it, in consequence of a corresponding number of projections proceeding from its walls. Other examples of the formation of spurious dissepiments producing changes in the ovary have been mentioned when speaking of those structures.

2nd. Other changes are produced in the ovary as it proceeds to maturity, in consequence of the great development of succulent parenchyma. Thus as already noticed, the thalamus of the Strawberry (*fig.* 645) becomes enlarged and succulent, and forms what is commonly termed the fruit, but the real fruit consists of the small dry carpels which are scattered over its surface. The pulp of the Guava, Gooseberry, Tomato, &c., in which the seeds are imbedded, appears to be produced from the placentas; that of the Orange, is of a similar nature.

Fig. 645.

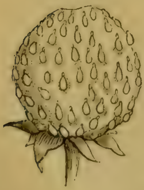


Fig. 645. Fruit of the Strawberry.

3rd. Other alterations are produced by the abortion, or obliteration of parts, as the ovary ripens. Thus the ovary of the Oak, and Hazel, consists of three cells, each of which contains two ovules,

but the fruit has only one cell and one seed, so that in the course of development, five ovules and one cell have become obliterated. In the Birch we have an ovary with two cells, containing one ovule in each, but the fruit is one-celled and one-seeded, so that here, one cell and one ovule have become obliterated. In the Ash, Horse-chestnut, Elm, and many other plants, similar changes are produced in the ovary by the abortion or obliteration of certain parts.

From the above examples it will be evident, that although the fruit consists essentially of the ripened pistil, yet that in the progress of the latter organ towards maturity, it becomes frequently much altered from its original structure, so that in order to have a clear idea of the nature of the fruit, it is important to examine that of the ovary, and trace its development up to the fruit.

General Characters of the Fruit.—The structure of the fruit resembling in all important particulars that of the ovary, the modifications which it presents, as to composition, position, &c., are described by similar terms. Thus we may have *simple* and *compound* fruits, as also *apocarpous* and *syncarpous* ones. Simple fruits, like simple ovaries, are normally *unilocular;* while a compound fruit may have one or more cells, according as the dissepiments are absent or present, and the number of cells is indicated by similar terms to those used when speaking of the compound ovary.

The fruit, again, is described as *superior* or *inferior*, in the same sense as those terms are used in speaking of the ovary. Thus a fruit is inferior, when it is formed from an inferior ovary, in which case the calyx necessarily enters into its composition, as in the Melon, Apple, Pear, Quince, &c.; or it is superior, as in the Poppy, Pea, &c., when the ovary is superior, and the calyx non-adherent.

The *base* of the fruit is that point by which it is united to the thalamus ; the *apex* is indicated by the attachment of the style, hence in those ovaries where the style is lateral or basilar, as in many Rosaceæ (*figs.* 623 and 624), Labiatæ, and Boragineæ, the organic apex of the fruit will be also thus situated, so that the geometrical and organic apices will be very different. The remains of the style frequently exist in the form of a little point on the fruit, which is then commonly described as *apiculate.* Some traces of the style may be usually observed, by which we are enabled to distinguish small fruits from seeds ; thus the fruits of the Ranunculus, those of Labiate Plants, the Boragineæ, Umbelliferæ, &c., are thus readily distinguished from seeds. Generally speaking, the style forms but a very small portion of the fruit, the greater part of it, together with the stigma, dying away soon after the process of fertilization has been effected; but in other cases, on the contrary, the style is not

Fig. 646.

Fig. 646. Fruit of the Traveller's-joy (*Clematis*). This fruit is called an Achenium, and is caudate or tailed.

only persistent but continues to grow, and it then forms a lengthened appendage to it, as in the Traveller's-joy (*Clematis*) (*fig.* 646), and in the Pasque-flower (*Anemone Pulsatilla*) (*fig.* 684); the style in these two cases being hairy, the fruit is called *caudate*, or tailed.

Pericarp.—The fruit when perfectly formed consists of two parts; namely, the shell or *pericarp*, and the seeds, which are contained within it. In the majority of cases the pericarp withers, and the fruit does not ripen when the seeds are abortive. There are, however, many exceptions to this; thus, many Oranges, Grapes, &c., produce no seeds, but the pericarp is nevertheless fully developed; and in the Bananas, Plantains, and Bread-fruit, the fruits develop most extensively, and become best adapted for food, when the seeds are chiefly abortive. Generally speaking, however, the development of the seeds and pericarp proceed together after the process of fertilization has been effected, and then only *perfect fruit* can be formed, for although in common language we apply the term fruit in those instances where no seeds are produced, yet strictly speaking such are not fully formed fruits, but only enlarged and swollen pericarps.

The pericarp, like the ovary of which it is essentially composed, possesses a placenta, to which the seeds are attached; and the same terms are used in describing the different kinds of placentation, as with those of the ovary; these kinds are usually more evident in the fruit.

Having now briefly alluded to the seeds as a component part of the perfect fruit, we must leave their particular examination till we have become acquainted with the structure of the ovules, and now proceed, therefore, to the description of the shell of the fruit or pericarp.

In the majority of fruits, the pericarp consists simply of the walls of the ovary in a modified state; but when the calyx is adherent, it necessarily presents a more complicated structure. The pericarp exhibits three layers or regions (*fig.* 679), an external, called the *epicarp* or *exocarp*, *cp*; a middle, the *mesocarp*, *me*; and an inner, the *endocarp*, *en*. The middle layer, being frequently of a fleshy or succulent nature, is also termed the *sarcocarp*; while the inner layer, from its hardness

in some fruits, is then termed the *stone* or *putamen*. When the pericarp consists simply of the matured walls of the ovary, its three parts correspond to the three parenchymatous layers of the carpellary leaf: thus the epicarp represents the epidermis of the under surface of a true leaf, or that on the outer surface of the ovary; the mesocarp corresponds to the general parenchyma of a leaf, or that of the ovary; and the endocarp to the epidermis on the upper surface of a leaf, or to the epithelium or inner lining of the ovary. When the calyx is completely united to the ovary, the relation of parts must necessarily differ, and probably somewhat vary according to circumstances: thus in the Apple, which we may take as an illustration of an inferior fruit, the epicarp corresponds to the epidermis of the under surface of the calyx; the mesocarp to the rest of the calyx, and the whole of the ovary except the inner lining, which corresponds to the endocarp. The parenchyma of the fruit, like that of the ovary and the true leaf, is traversed by fibro-vascular bundles.

In some cases the pericarp clearly indicates its analogy to the leaf, by remaining in a condition not very dissimilar to that organ folded inwards and united by its margins, as in the Bladder Senna (*Colutea arborescens*), (*fig.* 647); such a fruit is described as *foliaceous* or leafy. Generally speaking, however, one or more of the layers of the pericarp become more developed, by which its resemblance to the leaf is rendered much less evident. The epicarp generally retains an epidermal appearance, suffering but little change, except in becoming slightly thickened. The endocarp is more liable to alteration, and frequently differs much in appearance from the corresponding part of the leaf or ovary. Thus its cells sometimes become hardened by secondary deposits, and form a stony shell surrounding the seed, called the *putamen*, as already noticed. The mesocarp is the layer which commonly presents the greatest development, and differs most in appearance and texture from the general parenchyma of the leaf.

Fig. 647.

Fig. 647. Foliaceous bladdery legume of the Bladder Senna (*Colutea arborescens*).

The above remarks will be rendered more intelligible by being illustrated by a few examples taken from well-known fruits. In the Peach, Apricot, Cherry, Plum, &c., the separable skin is the epicarp; the pulpy part, which is eaten, the mesocarp or sarcocarp; and the stone enclosing the seed, the endocarp or putamen. In the Almond, the seed is enveloped by a thin woody shell, constituting the endocarp, which is itself surrounded by a

thin green layer, formed of mesocarp and epicarp. In the Apple and Pear, the skin is the epicarp; the fleshy part, which is eaten, the mesocarp or sarcocarp; and the core containing the seeds, the endocarp. A similar disposition of parts occurs in the Medlar, except that here the core becomes of a stony nature. In the Date, the outer brownish skin is the epicarp; the thin papery-like layer enclosing the seed is the endocarp; and the intermediate pulpy part is the mesocarp or sarcocarp. In the Walnut, the woody shell enveloping the seed, which is commonly termed the nut, is the endocarp; and the green covering of this, called the husk, consists of mesocarp and epicarp. In the Orange, the outer separable rind is composed of mesocarp and epicarp; and the thin membranous partitions which divide the pulp into separate portions form the endocarp; the edible pulp itself, as already noticed, is a development of a succulent parenchyma from the inner lining of the ovary, or probably from the placentas only. In the above fruits, and numerous others might be quoted, the different layers of the pericarp are more or less evident, but in some cases, as in the Nut, &c., these layers become so blended, that it is difficult, if not impossible, to distinguish them. The examples of fruits thus mentioned above, together with those previously alluded to, will show in a striking manner, the very varying nature and origin of those parts which are commonly eaten.

Sutures.—In describing the structure of the simple carpel, we found that it presented two sutures: one of which, called the ventral suture, corresponded to the union of its margins, and was consequently turned towards the axis or centre of the flower; and another, termed the dorsal suture, corresponding to the mid-rib of the carpellary leaf, and which was directed towards the circumference. The simple fruit being formed, in most cases, simply of the mature carpel, also presents two sutures, which are distinguished by similar names. These, like those of the carpel, may be frequently distinguished externally, either by a more or less projecting line, or by a slight furrow; thus in the Peach (*fig.* 677), Cherry, Plum, Apricot, &c., the ventral suture is very evident, although the dorsal suture has become nearly effaced; while in the Bladder Senna (*fig.* 647), Pea, and other fruits of the Leguminosæ, both dorsal and ventral sutures are clearly visible externally.

In a compound ovary with two or more cells, in which the placentation is axile, it must be evident, of course, that the dorsal sutures can be alone observed externally, as the ventral sutures of the component carpels are turned towards, and meet in the axis of the flower, and are hence removed from view; the number of dorsal sutures will also necessarily correspond to the number of component carpels of which such an ovary is formed. In a fruit presenting similar characters, we find of course a

similar disposition of the sutures. When an ovary, on the contrary, is formed of two or more carpellary leaves, the margins of which are not inflected, or only partially so, and is therefore one-celled, and presents parietal, or free central placentation, both ventral and dorsal sutures may be observed externally alternating with each other. The fruit, which is formed in a similar manner, necessarily presents a similar alternation of the sutures on its external surface.

Dehiscence.—The pericarp at certain periods, which vary in different plants, but commonly when the fruit is ripe, either opens, so as to allow the seeds to escape, or it remains closed, and the seeds can only become free by its decay. In the former case, the fruit is said to be *dehiscent;* in the latter, *indehiscent.* Those fruits, such as the Nut, the Cherry, Apricot, Plum, Date, &c., which have very hard or fleshy pericarps, are usually indehiscent.

Dehiscent fruits open in various ways:—1st, By a splitting down in the line of one or both of the sutures; or at the junction of the component carpels only, or at those points, as well as at the dorsal sutures; in all such cases the pieces into which the fruit separates are called *valves*, and these valves, when the fruit is normal in its structure, are either equal in number to the cells, or component carpels, or they are twice as numerous. Thus in simple carpels, which only open by the ventral or dorsal suture, there will be only one valve corresponding to the one carpel, or its one cell; but if they open by both sutures, there will be two valves. In compound ovaries composed of several cells, the valves will be equal in number to the cells, or component carpels, if the dehiscence only takes place by the dorsal suture, or in the line of union of the component carpels; or they will be double the number, if the dehiscence takes place by both those parts of the fruit. In compound one-celled fruits, the valves will be equal in number to the component carpels, if the dehiscence occurs only by the ventral or dorsal sutures, or double, if by both. When there is a distinct axis left after the separation of the valves, this is called the *columella* (*figs.* 660 and 661, *a*). According to the number of valves, the fruit is described as *univalvular*, *bivalvular*, *trivalvular*, *multivalvular*, &c.

2nd, Dehiscence, instead of taking place longitudinally or in a valvular manner, sometimes occurs in a transverse direction, by which the upper part of the fruit separates from the lower like the lid from a jar or box; and 3rd, It may take place in an irregular manner by little pores. We have thus three kinds or classes of dehiscence, which are called respectively:—1. *Valvular*, 2. *Transverse* or *circumscissile*, and 3. *Porous.*

1. VALVULAR DEHISCENCE.—This may be either partial or complete; thus in the *Dianthus* (*fig.* 649), *Lychnis* (*fig.* 648),

Fig. 648. *Fig.* 649. *Fig.* 650.

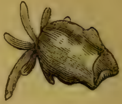


Fig. 648. Fruit of *Lychnis.*—*Fig.* 649. Fruit of *Dianthus.*—*Fig.* 650. Fruit of Mignonette (*Reseda*).

and many other Caryophyllaceous Plants, the dehiscence only takes place at the upper part of the fruit, which then appears toothed, the number of teeth corresponding to that of the valves. A somewhat similar mode of partial dehiscence occurs in certain Saxifrages, and in the Mignonette (*fig.* 650), &c.; in the latter plant one large orifice may be observed at the summit of the fruit at an early stage of its growth, and long before the seeds are ripe. All these modes of partial dehiscence are by some botanists placed under the head of porous dehiscence, but from which, in most cases at least, they are readily distinguishable. At other times, the separation of the fruit into valves is more or less complete, so that the nature of the dehiscence is at once evident. We now pass to consider the various modifications of such forms of valvular dehiscence.

In fruits which are formed of but one carpel, the dehiscence may take place by the ventral suture only, as in the Hellebore, Columbine (*fig.* 651), and Pæony (*fig.* 683); or by the dorsal suture only, as in some Magnolias (*fig.* 652); or by both dorsal and ventral sutures, as in the Pea (*fig.* 653), Bean, and many other Leguminous Plants. This form of dehiscence is commonly known as *sutural.*

In compound fruits having two or more cells with axile placentation, there are three leading forms of dehiscence, which are called respectively, *septicidal*, *loculicidal*, and *septifragal.*

A. *Septicidal Dehiscence.*—In this form, the fruit is separated into its component carpels by a division taking place between the two halves of each dissepiment (*fig.* 654). It is seen in the *Colchicum*, in the *Scrophularia*, and the *Rhododendron*, &c. In this dehiscence each valve corresponds to a carpel, and the valves are said to have their margins turned inwards. In this form of dehiscence, the placentas with the seeds attached, are either carried away with the valves (*fig.* 655), as in the *Colchicum*, &c. (*fig.* 654); or the valves break

Fig. 651. *Fig.* 652. *Fig.* 653.

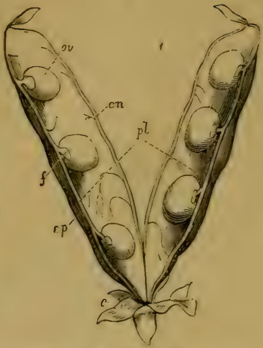
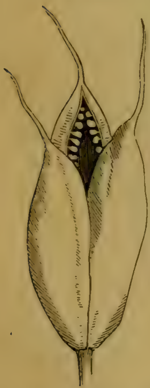


Fig. 651. Follicle of Columbine (*Aquilegia*), dehiscing by ventral suture. —— *Fig.* 652. Follicles of *Magnolia glauca*, dehiscing by their dorsal suture. The seeds are suspended from the carpels by long cords. —— *Fig.* 653. Legume of the Pea which has opened by both dorsal and ventral sutures ; hence it is two-valved. *c.* Calyx. *ep.* Epicarp. *pl.* Placenta. *ov.* Seeds attached to the placenta by a funiculus or stalk, *f.* *en.* Endocarp.

Fig. 654. *Fig.* 655. *Fig.* 657. *Fig.* 658.



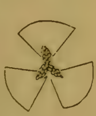


Fig. 656.

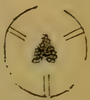


Fig. 659.

Fig. 654. Capsule of the Meadow Saffron (*Colchicum autumnale*), showing septicidal dehiscence. —— *Fig.* 655. Diagram of septicidal dehiscence, showing the placentas and seeds carried away with the valves. —— *Fig.* 656. Diagram of septicidal dehiscence, showing the valves breaking away from a central column formed by the union of the placentas. —— *Fig.* 657. Capsule of a species of *Hibiscus*, dehiscing loculicidally. *v, v, v.* Valves. *c.* Dissepiments. *g.* Seeds. —— *Fig.* 658. Diagram of loculicidal dehiscence, in which the valves carry the placentas with them. —— *Fig.* 659. Diagram of loculicidal dehiscence, in which the valves have separated from the placentas which remain as a central column.

away from the placentas, which remain united and form a central column (*fig.* 656).

B. *Loculicidal Dehiscence.*—This is said to occur, when each

carpel opens by its dorsal suture or through the back of the cells, the dissepiments remaining undivided (*fig.* 657). Here, each valve is composed of the united halves of two adjoining carpels, and the valves are said to bear the dissepiments in the middle. Examples may be seen in the Lily, Iris (*fig.* 690), and *Hibiscus* (*fig.* 657). As in septicidal dehiscence, the valves may either carry the placentas and seeds with them (*fig.* 658), as in the Iris; or they may break away from the placentas, and leave them united in the form of a central column (*fig.* 659); or each carpel may simply open at its dorsal suture, and the valves bearing the dissepiments may remain attached to the placentas.

In some forms of septicidal dehiscence the carpels separate without opening, as in the *Digitalis*, in which case they may afterwards open by their dorsal sutures, or in a loculicidal manner. In other cases, the axis is prolonged in the form of a columella or carpophore, as in the Mallow, Castor-oil Plant (*fig.* 660, *a*), and in the Geraniaceæ (*fig.* 661, *a*), Umbelliferæ

Fig. 660.

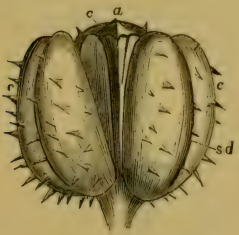


Fig. 661.

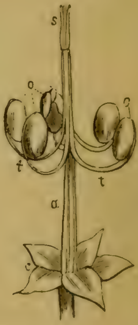


Fig. 660. Fruit of Castor-Oil Plant (*Ricinus communis*), dehiscing in a septicidal manner. *c, c, c.* Carpels. *a.* Columella. *sd.* Dorsal suture where each carpel ultimately opens.——*Fig.* 661. Fruit of a species of Geranium. *c.* Persistent calyx. *a.* Axis or carpophore from which the carpels, *o, o,* with their styles, *t, t,* are separating. *s.* Stigmas.

(*fig.* 697), &c., and the carpels which are united to it also separate without opening. Such carpels frequently open afterwards by their dorsal sutures (*fig.* 660, *sd*). When such carpels separate with a certain amount of elasticity from the axis to which they are attached, as in some Euphorbiaceæ, they have been called *cocci* (*fig.* 660). By some botanists, all carpels which thus separate from the axis in a septicidal manner are termed *cocci*, and the fruit is described as *dicoccous, tricoccous,* &c., according to their number. In some fruits, such as those of the *Linum catharticum*, the carpels open first by their dorsal

suture, and then separate from each other in a septicidal manner.

C. *Septifragal Dehiscence.* — In this form of dehiscence the carpels open by their dorsal sutures, and at the same time the dissepiments separate from the walls and remain united to one another and to the axis, which in this case is generally more or less prolonged (*figs.* 662 and 663). Here each valve is composed of the two halves of adjoining carpels. This form of dehiscence may be seen in the *Datura* (*fig.* 663, 2), and *Cedrela* (*fig.* 662). The placentas bearing the seeds are here attached to the axis between the dissepiments (*fig.* 662, *a*).

Fig. 662.

Fig. 663.

Fig. 662. Capsule of *Cedrela angustifolia*, showing septifragal dehiscence. *v*, *v*, *v*. Valves. *a*. Axis bearing the dissepiments, *c*, *c*, and seeds, *g*. —— *Fig.* 663. Diagram illustrating septifragal dehiscence.

In compound fruits with one cell having parietal or free central placentation, we have two forms of dehiscence; these are analogous to the ordinary septicidal and loculicidal kinds just described.

Thus in compound fruits with parietal placentation, the dehiscence may take place:—either through the confluent margins or ventral sutures of the adjoining carpels, so that each placenta is divided into its two lamellæ, as in the Gentian (*fig.* 664), in which case the dehiscence is analogous to the septicidal form, and each

Fig. 663, 2.

Fig. 663, 2. Capsule of *Datura Stamonium*, showing septifragal dehiscence.

x 2

valve, therefore, represents one of the component carpels of the fruit; or the dehiscence may take place through the dorsal sutures, as in the Heart's-ease (*fig.* 665), in which case it is analogous to the loculicidal dehiscence, and each valve is composed of the adjoining halves of two carpels. These forms may be readily distinguished by the varying attachment of the placentas and seeds in the two cases; thus in the former instance, each valve will bear the placentas and seeds on its two margins (*fig.* 664), and the valves are said to be *placentiferous at their borders;* in the latter, the placenta and seeds will be attached to the centre of each valve (*fig.* 665), and the valves are then said to be *placentiferous in their middle.* It sometimes happens, as in the fruit of the *Chelidonium* (*fig.* 667), and Wallflower (*fig.* 666), &c., that the placentas bearing the seeds remain undivided, and the valves break away from them, so that they are left attached to a frame or *replum* (*fig.* 600).

Fig. 664.

Fig. 665.

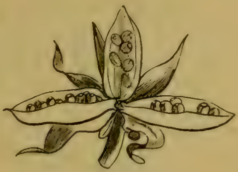


Fig. 666.

Fig. 667.

Fig. 664. Fruit of a Gentian dehiscing in a septicidal manner. —— *Fig.* 665. Fruit of Heart's-ease (*Viola tricolor*), dehiscing in a loculicidal manner. —— *Fig.* 666. Fruit or siliqua of the Wallflower, showing the separation of two valves from a replum. —— *Fig.* 667. Fruit of Celandine (*Chelidonium majus*), with the valves separating from the placentas.

In compound fruits with a free central placentation, the same forms of dehiscence occur as in those with parietal placentation, but here it is difficult in many cases to speak positively as to the nature of the dehiscence, from the absence of seeds or dissepiments upon the valves. The means usually adopted in such cases, is to count the number of the valves and compare their position with that of the divisions of the calyx. Thus as

the different whorls of the flower, in a regular arrangement alternate with each other, the component carpels of the fruit should alternate with the divisions or sepals of the calyx. If the fruit therefore separates into as many portions as there are parts or sepals to the calyx, and if these valves are then placed alternate to them, they represent the component carpels, and the dehiscence is consequently analogous to the septicidal form; if, on the contrary, the valves are equal and opposite to the divisions of the calyx, each valve is composed of the adjoining halves of two carpels, and the dehiscence is analogous to the loculicidal form. Sometimes the number of valves is double that of the calycine segments, or sepals, in which case, each valve is formed of half a carpel, the dehiscence of the fruit having taken place both by its dorsal and ventral sutures.

In all the above forms of valvular dehiscence, the separation may either take place from above downwards, which is by far the more usual form (*figs.* 654, 657, and 662); or occasionally from below upwards, as in the Mahogany (*Swietenia Mahagoni*), *Chelidonium* (*fig.* 667), Cruciferous Plants (*fig.* 666), &c.

2. Transverse or Circumscissile Dehiscence. — In this kind of dehiscence, the opening takes place by a transverse line through the fruit across the sutures, so that the upper part is separated from the lower like the lid of a soap-box, as in *Hyoscyamus* (*fig.* 668), *Anagallis* (*fig.* 692), Purslane, &c. Sometimes the dehiscence only takes place half round the fruit, as in *Jeffersonia*, in which case the lid remains attached to the fruit on one side, as by a hinge. The transverse dehiscence of fruits resembles certain forms of calyx, as that of *Eucalyptus* and *Eschscholtzia*, where the upper part separates from the lower like a lid. The fruits or pericarps which present transverse dehiscence may be supposed to be formed, either of carpellary leaves in which the laminæ are articulated to the petioles, as in the Orange (*fig.* 300), and which become separated at the point of articulation, so that the united petioles form the lower part of the fruit, and the united laminæ the upper; or it may result from the prolongation and hollowing out of the thalamus, and the articulation of the carpellary leaves to its circumference, so that in the dehiscence the lower part of the fruit is formed by the concave thalamus, and the upper part by the carpellary leaves; thus resembling the separation of the calyx in *Eschscholtzia* from the thalamus.

Fig. 668.

Fig. 668. Fruit of Henbane (*Hyoscyamus*) with transverse dehiscence. This fruit is termed a pyxis, which is a kind of capsule.

Fig. 669.

Fig. 669. Pyxis of the Monkey-pot (*Lecythis ollaria*), with transverse dehiscence.

In the Monkey-pot (*Lecythis*) (*fig.* 669), the lower part of the ovary is adherent to the tube of the calyx, and the upper portion is free; when dehiscence takes place, it does so in a transverse manner and at the part where the upper free portion joins the lower adherent one, so that it would appear as if the adherence of the calyx had some effect in this case in producing the transverse dehiscence. Such fruits are sometimes termed *operculate*, a term which is also applied by some botanists to all forms of transverse dehiscence in which the upper portion of the fruit or pericarp separates from the lower in the form of a lid or *operculum*.

Mr. Hincks, in a paper published in vol. xvii. of the *Annals of Natural History*, thus accounts for the transverse dehiscence of the fruit; he thinks "that it arises from the force of cohesion of the parts of the circle, the absence of any of the causes favourable to dehiscence along the midrib of the carpellary leaf, and the operation of some force pressing either from without or from within on one particular line encircling the fruit."

Transverse dehiscence may also occur in fruits which are formed by a single carpel, as well as in the compound fruits mentioned above. Thus the legumes of *Coronilla*, *Hedysarum* (*fig.* 670), *Ornithopus*, &c., separate when ripe into as many portions as there are seeds. The separation taking place in these cases has been supposed to be effected by a process called *solubility*. Mr. Hincks thus explains it in the paper above alluded to; he says "the intervals between the seeds being sufficient to admit of the sides of the fruit cohering (which is promoted in particular instances by special causes), the swelling of the seeds afterwards stretches the parts over them in a degree which this coherence prevents from being equally distributed, drags the tissue forcibly from the junctures which are fixed points, and thus there being a strain in each direction from the middle line of the juncture, the contraction of drying in the ripening of the fruit effects the separation."

Fig. 670.

Fig. 670. Fruit of a species of Saintfoin (*Hedysarum*) separating transversely into one-seeded portions.

Some botanists regard such legumes as formed of folded pinnate carpellary leaves analogous to the ordinary pinnate leaves of the same plants,

the divisions taking place at the points of union of the different pairs of pinnæ.

3. Porous Dehiscence.—This is an irregular kind of dehiscence, in which the fruits open by little pores or slits formed in their substance by a process called *rupturing*. These openings may be either situated at the apex, base, or side of the fruit, hence they are described accordingly, as *apicular*, *lateral*, or *basilar*. Examples of this kind of dehiscence occur in the Poppy (*fig.* 428), in which a number of pores are placed beneath the peltate disc to which the stigmas are attached; in the *Antirrhinum* (*fig.* 611), where there are two or three orifices, one of which is situated near the summit of the upper carpel, the other (one or two) in the lower; and in various species of *Campanula*, &c. (*figs.* 671 and 672). In the latter the calyx is adherent to the ovary, and the pores which have a very irregular appearance at their margins, penetrate through the walls of the pericarp formed by the adherent calyx and ovary; these pores correspond to the number of cells in the ovary, and are either situated at the side (*fig.* 671), or towards the base (*fig.* 672).

Fig. 671.

Fig. 672.

Fig. 671. Fruit of a species of Campanula. *p*. Pericarp. *t*, *t*. Pores at the sides. *c*, *c*. Persistent calyx united with the pericarp. —— *Fig.* 672. Fruit of a Campanula dehiscing by pores at its base.

Kinds of Fruit.—A number of different kinds of fruit have been distinguished and named, and several classifications of the same have been proposed at various times, but at present there is but little accordance among botanists upon this subject. This is much to be regretted, as there can be no doubt but that a strictly definite phraseology of fruits, founded essentially upon the structure and position of the ovary, would be of great value in descriptive botany. The difficulties attending this subject have been also much increased, by the same names having been given by different authors to totally distinct kinds of fruits, and even to different classes of fruits. In a work like the present it would be impossible, and indeed would only lead to confusion, if it were attempted to describe all the different kinds of fruits that have received names. At the same time, I consider the subject of far too much importance to be hastily disposed of, and I shall accordingly devote as much

space as possible to this intricate subject. Those who wish to investigate the matter further than my limits will allow me to do, would do well to consult *Lindley's Introduction to Botany*, for of all recent writers upon Carpology, this author has done most to reduce a perfect chaos to at least some degree of regularity, and I have accordingly made much use of his labours in defining the different kinds of fruits. The classification however, adopted here, differs in some particulars from Dr. Lindley's. We have taken the pistil as our guide, and have accordingly used the terms when applied to fruits, in precisely the same sense as previously defined in treating of that organ.

The leading divisions of the classification here adopted, are as follows:—

1. Fruits formed by a Single Flower.
   a. Simple Fruits.
   b. Apocarpous Fruits.
   c. Syncarpous Fruits.
2. Fruits formed by the combination of several Flowers.

1. Fruits formed by a Single Flower.

a. Simple Fruits.—*By a simple fruit, we mean one which is formed of a single carpel, and only one produced by a single flower.* By some botanists this term is used to signify all fruits of whatever nature, which are the produce of a single flower; thus including the *simple*, *apocarpous*, and *syncarpous* fruits of the classification here adopted. We shall describe four kinds of these fruits:—namely, the Legume, the Lomentum, the Drupe, and the Utricle.

1. *Legume or Pod.*—This is a superior, one-celled, one or many seeded fruit, dehiscing by both the ventral and dorsal sutures, so as to form two valves, and bearing its seed or seeds on the ventral suture. Examples occur in the Pea (*fig.* 653), Bean, Clover, and in most plants of the order Leguminosæ, which has derived its name from this circumstance. The legume assumes a variety of forms, but it is generally more or less convex on its two surfaces, and nearly straight; at other times, however, it becomes twisted so as to resemble a screw (*fig.* 675), or like a snail twisted, as in some species of *Medicago* (*fig* 674), or coiled up like a caterpillar, as in *Scorpiurus sulcata* (*fig.* 673), or curved like a worm, as in *Cæsalpinia coriaria*, or it assumes a number of other irregular forms. Certain deviations from the ordinary structure of a legume are met with in some plants; thus, in *Astragalus* (*fig.* 604), and *Oxytropis*, it is two-celled, in consequence of the formation of a spurious dissepiment, which in the first plant proceeds from the dorsal suture, in the latter from the ventral. At other times, a number of spurious horizontal dissepiments are formed, by which the legume becomes divided into

as many cells as there are seeds, as in *Cathartocarpus Fistula* (*fig.* 599); in which plant also the legume is indehiscent, but the two sutures are clearly marked externally. The nature of the above fruits can only be accurately ascertained by examining the ovary, and tracing its development. Other indehiscent legumes are also met with, as in *Arachis*, *Pterocarpus*, &c., in which there is sometimes no evident mark of the sutures externally; these will, however, frequently split into two valves like those of a pea, if a little pressure be applied, as in the ordinary process of shelling peas.

2. *The Lomentum.*—This is a kind of legume which is contracted in a moniliform manner between each seed, as in *Hedysarum* (*fig.* 670), *Ornithopus*, *Acacia Sophora* (*fig.* 676).

Fig. 673.

Fig. 675.

Fig. 676

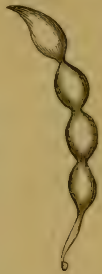


Fig. 674.

Fig. 673. Coiled up legume of *Scorpiurus sulcata*. —— *Fig.* 674. Snail-like legume of *Medicago orbiculata*. —— *Fig.* 675. Spiral or screw-like legume of Lucerne (*Medicago*). —— *Fig.* 676. Indehiscent lomentum of a species of *Acacia*.

It is sometimes called a *lomentaceous legume* or *pod.* This fruit, together with the former, characterise the plants of the Leguminosæ. When the lomentum is ripe, it commonly separates into as many pieces as there are contractions on its surface (*fig.* 670), or it remains entire (*fig.* 676); in the latter case, the seeds are separately enclosed in cavities which are formed by the production of as many internal spurious dissepiments as there are external contractions.

3. *The Drupe.*—This is a superior, one-celled, one or two seeded, indehiscent fruit, having a fleshy or pulpy sarcocarp, a hard or bony endocarp, and the pericarp altogether, separable into its component parts, namely, of epicarp, sarcocarp, and endocarp. This is sometimes called a *stone-fruit.* Examples occur in the Peach (*figs.* 677 and 678), Apricot, Plum, Cherry (*fig.* 679), Olive, &c. In the Almond, the fruit presents all

Fig. 677.

Fig. 678.

Fig. 677. Drupe of the Peach. —— *Fig.* 678. The same cut vertically.

the characters of the drupe, except that the sarcocarp is of a toughish texture, instead of being succulent. Many fruits, such as the Walnut, Coco-nut, &c., are sometimes termed drupes, but improperly so, as they are in reality compound, or formed originally from two or more carpels, besides presenting other distinctive characters. A number of drupes aggregated together on a common receptacle, form collectively a kind of Etærio (see ETÆRIO). Any fruit which resembles in its general characters the drupe, is frequently termed *drupaceous* or *drupe-like.*

4. *The Utricle* is a superior, one-celled, one or few-seeded fruit, with a thin, membranous, loose pericarp, not adhering to the seed, generally indehiscent, but sometimes opening in a transverse manner. Examples of this kind of fruit may be seen in *Amaranthus*, *Chenopodium*, &c. (*fig.* 680).

Fig. 679.

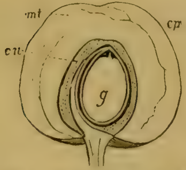


Fig. 680.

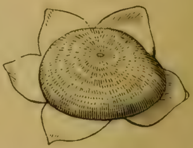


Fig. 679. Vertical section of the drupe of the Cherry (*Cerasus*). *cp.* Epicarp. *en.* Endocarp. *mt.* Mesocarp. *g.* Seed with embryo. —— *Fig.* 680. Utricular fruit of *Chenopodium*, surrounded by the persistent calyx.

b. APOCARPOUS FRUITS.—*Under this name we include those fruits which are formed of a single carpel, but of which several are produced by a single flower.* The simple fruits just described are frequently placed by botanists under this head, together

with those to which we are now about to allude. Apocarpous fruits are also sometimes termed *multiple*, and this latter term is again applied by others, to those fruits which are the produce of several flowers. We distinguish three kinds of Apocarpous fruits:—The Follicle, the Achænium, and the Etærio.

1. *The Follicle.*—This is a superior, one-celled, one or many-seeded fruit, dehiscing by the ventral suture only, and consequently one-valved (*fig.* 651). By the latter character it is known at once from the legume, which opens as we have seen by two sutures, and is two-valved; in other respects the two are alike. In *Magnolia glauca* (*fig.* 652), and others, the follicle sometimes opens by the dorsal suture instead of the ventral. Examples occur in the Columbine (*figs.* 651 and 681), Hellebore, Larkspur, Aconite (*fig.* 682), &c., in which the fruit is composed of three or more follicles placed in a circular manner on the thalamus; in the Asclepias, Periwinkle, and Pæony (*fig.* 683), where each flower generally forms two follicles; in the *Liriodendron*, *Magnolia*, &c. (*fig.* 652), where they are numerous, and arranged in a spiral manner on a more or less elongated thalamus. It rarely happens that a flower produces but a single follicle; but this sometimes occurs in the Pæony, &c. The two follicles of *Asclepias* are more or less united at their base, and the seeds, instead of remaining attached to

Fig. 681.

Fig. 681. Follicles of the Columbine (*Aquilegia*).

Fig. 682.

Fig. 683.

Fig. 682. Follicles of the Aconite (*Aconitum*).——*Fig.* 683. Follicles of the Pæony (*Pæonia*).

the ventral suture, as is the case in the true follicle, lie loose in the cavity of the fruit. This double fruit has therefore received the distinctive name of *Conceptaculum*.

2. *The Achænium* is a superior, one-celled, one-seeded fruit, with a dry indehiscent pericarp, which is separable from the seed, although closely applied to it. Linnæus mistook some of these achænia for seeds, and called the plants producing them, *gymnosperms* (naked-seeded). They may be, however, generally distinguished from seeds, by presenting on some points of their surface the remains of the style. This style is sometimes very evident, as in the Clematis (*fig.* 646), and Anemone (*fig.* 684). Examples may be seen in the Clematis and Anemone, and in the plants of the orders Labiatæ (*fig.* 594), and Boragineæ (*fig.* 685). In rare cases we find a flower producing but a single achænium.

Fig. 684.

Fig. 685.

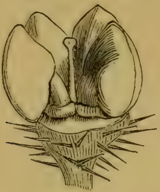


Fig. 684. Vertical section of an achænium of the Pasque Flower (*Anemone Pulsatilla*). The fruit is said to be tailed in this instance in consequence of being surmounted by a feathery style. —— *Fig.* 685. Achænia or fruits of Bugloss (*Lycopsis*).

3. *The Etærio.* — When the achænia borne by a single flower are so numerous that they form more than a single whorl or series, they constitute collectively an *etærio*. Examples may be seen in the Ranunculus (*fig.* 530), and Adonis (*fig.* 592), where the achænia are placed upon a convex thalamus of a dry nature; and in the Strawberry (*fig.* 645), where they are placed upon a fleshy thalamus; hence, in the Strawberry, the so-called seeds, are in reality so many separate achænia, while the part to which the Strawberry owes its value as a fruit is the succulent thalamus.

In the fruit of the Rose (*fig.* 439), the achænia instead of being placed upon an elevated thalamus as in the ordinary etærio, are situated upon a concave thalamus to which the calyx is attached. This modification of the ordinary etærio has been made a separate fruit by some botanists, to which the name of *Cynarrhodum* has been given. A similar kind of fruit also occurs in *Calycanthus*.

In the Raspberry (*fig.* 591) and Bramble, we have a kind of etærio formed of a number of little drupes or drupels, crowded together upon a dry thalamus. The etærio and its modifications are placed by Lindley under a class of fruits called by him *aggregate fruits*, the characters of which are, "Ovaria strictly simple; more than a single series produced by each flower."

The term aggregate is by some botanists applied to fruits which are the produce of several flowers.

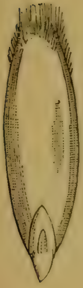
c. SYNCARPOUS FRUITS.—*Under this head we include all fruits which are formed by the more or less complete combination of two or more carpels, and only one of which is produced by a single flower.* In the two former classes the fruits are formed of simple ovaries; in this from those of a more or less compound nature. In describing these fruits we shall follow generally the classification of Dr. Lindley. Thus in the first place, we divide them into two divisions according as they are superior or inferior; and each of these divisions is again divided into others, derived from the dry or fleshy nature of their pericarp, and their dehiscent or indehiscent character.

Division 1. *Superior Syncarpous Fruits.*

a. WITH A DRY INDEHISCENT PERICARP.

1. *The Caryopsis* is a superior, one-celled, one-seeded, indehiscent fruit, with a thin dry membranous pericarp completely and inseparably united with the seed (*figs.* 686 and 687). This resembles the achænium, but it is distinguished by the complete union which exists between the pericarp and the seed. It is, moreover, generally considered as being of a compound nature, from the presence of two or more styles and stigmas to

Fig. 686. *Fig.* 687. *Fig.* 688.



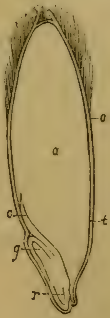


Fig. 686. Caryopsis or fruit of the Oat. ——*Fig.* 687. The same cut vertically. *o.* Pericarp. *t.* Testa or integuments of the seed. *a.* Albumen. *c.* Cotyledon. *g.* Gemmule or plumule. *r.* Radicle.——*Fig.* 688. Samara or fruit of the Maple (*Acer*).

the ovary (*fig.* 586). It is found in the Oat, Maize, Rye, Wheat, Barley, and generally in Grasses. These fruits, like the achænia, are commonly called seeds, but their true nature is at once evident when they are examined in their early state.

2. *The Samara* is a superior, two or more celled fruit, each cell being dry, indehiscent, few-seeded, and having its pericarp extended into a winged expansion. Each cell of the samara is in fact an achænium with a winged margin. Examples occur in the Sycamore (*fig.* 688), Ash, Elm, &c. By some botanists each winged portion of such a fruit is called a samara, and thus the fruit of the Sycamore (*fig.* 688), is considered to be formed of two united samara.

3. *The Carcerule* is a superior, many-celled fruit, each cell being dry, indehiscent, and one or few-seeded, and all more or less cohering by their united styles to a central axis. The Common Mallow (*fig.* 689) is a good example of this fruit. Each cell of the carcerule does not differ essentially from an achænium; which is also the case, as just noticed, with those of the samara, and hence the latter fruit may be regarded as but a winged modification of the carcerule.

Fig. 689.

Fig. 689. Carcerule or fruit of the Mallow (*Malva*).

4. *The Amphisarca* is a "superior, many-celled, indehiscent, many-seeded fruit, indurated, or woody externally, pulpy internally." Examples, *Omphalocarpus*, *Adansonia*, *Crescentia*.

b. WITH A DRY DEHISCENT PERICARP.

1. *The Capsule* is a superior, one or more celled, many-seeded, dry, dehiscent fruit. The dehiscence may either take

Fig. 690.

Fig. 691.

Fig. 692.

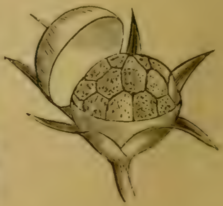


Fig. 690. Capsule of the Iris, opening in a loculicidal manner.——*Fig.* 691. Spirally arranged capsule of a species of *Helicteres*.——*Fig.* 692. Pyxis or fruit of Pimpernel (*Anagallis*) dehiscing transversely.

place by valves, as in Colchicum (*fig.* 654), Iris (*fig.* 690), and *Datura* (*fig.* 663, 2), &c.; or by pores, as in the Poppy

(*fig.* 428) and Antirrhinum (*fig.* 611); or *transversely*, as in the Anagallis (*fig.* 692), Henbane (*fig.* 668), &c.; in the latter case the fruit has received the distinctive name of *Pyxis* or *Pyxidium*. The capsule is one-celled in the Mignonette (*fig.* 650), Heart's-ease (*fig.* 665), Gentian (*fig.* 664), &c.; it is two or more celled in the Scrophularia (*fig.* 693), Colchicum (*fig.* 654), Iris, (*fig.* 690), Datura (*fig.* 663, 2), &c. It assumes various forms, some of which are remarkable, as those of *Helicteres* (*fig.* 691), where it is composed of five carpels twisted together in a spiral form, and *Illicium anisatum*, where the carpels are arranged in a stellate manner. It is a very

Fig. 693.

Fig. 693, 2.

Fig. 693. Fruit or capsule of a species of *Scrophularia*, dehiscing in a septicidal manner. ——*Fig.* 693, 2. Fruit of Sandbox tree (*Hura crepitans*). It is composed of fifteen carpels, which burst from the axis with great force.

common fruit, and is found almost universally in some natural orders, as Papaveraceæ, Caryophyllaceæ, Primulaceæ, Scrophulariaceæ, Liliaceæ, Iridaceæ, Gentianaceæ, &c., &c.

When a capsule consists of three or more cells, which separate from the axis, and burst with elasticity (*cocci*), as in *Ricinus* (*fig.* 660), *Euphorbia*, *Hura crepitans* (*fig.* 693, 2), &c., it has been termed a *Regma*.

In the Campanulas (*figs.* 671 and 672), we have a fruit which resembles the ordinary capsule in every respect, except that it is inferior. Such a form of capsule has received the name of *Diplotegia*. (See p. 322.)

2. *The Siliqua* is a superior, one or two-celled, many-seeded, long, narrow fruit, dehiscing by two valves separating from below upwards, and leaving the seeds attached to two parietal placentas, which are commonly connected together by a spurious vertical dissepiment, called a *replum* (*fig.* 600). The placentas are opposite to the lobes of the stigma, instead of alternate, as is the case in all fruits which are regular in structure. When the replum extends entirely across the fruit it is two-celled; if only partially, it is one-celled. Examples of this fruit occur in the Wallflower (*fig.* 666), Stock, Cabbages, and in many other

Cruciferæ. When a fruit possesses the general structure of the siliqua, but with the lobes of the stigma alternate with the placentas, as in *Chelidonium* (*fig.* 667), it has been named a *Ceratium* or a *siliquiform capsule.*

The siliqua is sometimes contracted in the spaces between each seed, like the lomentum, in which case it is indehiscent, as in *Raphanus maritimus* and *sativus*, &c. This is called a *Lomentaceous siliqua.*

3. *The Silicula.* This fruit resembles the siliqua in every respect, except its length. Thus the *siliqua*, may be described as long and narrow — the *silicula*, as broad and short. Examples occur in the Shepherd's Purse (*fig.* 694), and Scurvy-grass.

Fig. 694. *Fig.* 695. *Fig.* 696.

Fig. 694. Silicula of Shepherd's Purse (*Thlaspi*).——*Fig.* 695. Transverse section of the fruit of the Orange (*Citrus Aurantium*). *p.* Epicarp. *e.* Mesocarp. *d.* Endocarp. *s.* Seed.——*Fig.* 696. Monstrous development of the fruit of the Orange, in which the carpels, *ce*, and *ci*, are more or less distinct instead of being united. (From *Balfour.*)

The siliqua or the silicula are found universally and only in plants of the order Cruciferæ.

c. WITH FLESHY AND INDEHISCENT PERICARPS.

1. *The Hesperidium* is a superior, many-celled, few-seeded, indehiscent fruit, consisting of a separable rind, formed of the epicarp and mesocarp combined together (*fig.* 695, *p e*), and having an endocarp *d* projecting internally in the form of membranous partitions, which divide the pulp into a number of portions or cells, which are easily separated from each other. This pulp, as already noticed, is either a development of succulent parenchyma from the inner lining of the ovary generally, or from the placentas only. The seeds, *s*, are imbedded in the pulp, and attached to the inner angle of each of the divisions into which the fruit is divided. By some botanists the orange is considered as a *berry* with a leathery rind, but the latter is essentially different in its origin, as it is an inferior fruit. The fruit of the Orange, Lemon,

Lime, Shaddock, &c., are examples of the hesperidium. It is by no means uncommon to find the carpels composing the fruit of the Orange, &c., in a more or less separated state (*fig.* 696), and we have then produced what are called "horned oranges," "fingered citrons," &c., and the fruit becomes somewhat apocarpous, instead of altogether syncarpous.

2. *The Tryma* is a superior, one-celled, one-seeded, indehiscent fruit, having a separable, fleshy or leathery rind, consisting of epicarp and mesocarp, and a hard two-valved endocarp, from the inner lining of which spurious dissepiments extend so as to divide the seed into deep lobes. It differs but little from the ordinary drupe, except in being formed from an originally compound ovary. Example, the Walnut.

3. *The Nuculanium.* This fruit, of which the Grape may be taken as an example, does not differ in any important characters from the berry, except in being superior. (See BERRY p. 322.) This name is sometimes applied to a kind of pome, where the cells become hard and stony, as in the Medlar.

Division 2. Inferior Syncarpous Fruits.

a. WITH A DRY INDEHISCENT PERICARP.

1. *The Cremocarp* is an inferior, dry, indehiscent, two-celled, two-seeded fruit. The two cells or halves of which this fruit is composed are joined face to face to a common axis or *carpophore*, from which they separate when ripe, but to which they always remain attached by a slender cord which suspends them. (*fig.* 697). Each half-fruit is termed a *hemicarp* or *mericarp*, and the inner face the *commissure.* Each portion of the fruit resembles the achænium, except in being inferior; hence the name *diachænium* has been given to this fruit. Examples of the cremocarp as above defined are only found in the Umbelliferæ, in the plants of which order it is universal. By Lindley, the definition of cremocarp is extended so as to include fruits of a similar nature, but which contain more than two cells, as, for instance, those of *Aralia.*

Fig. 697.

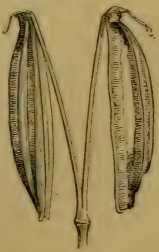


Fig. 697. Cremocarp, or fruit of Angelica.

2. *The Cypsela.* This differs in nothing essential from the achænium, except in being inferior and of a compound nature. It occurs in all plants of the order Compositæ. When the calyx is pappose it remains attached to the fruit, as in Salsafy and Dandelion.

3. *The Glans* or *Nut* is an inferior, dry, hard, indehiscent, one-celled, one or two-seeded fruit, produced from an ovary of two or more cells, with one or more ovules in each cell, all of which become abortive in the progress of growth except one or two. The three layers constituting the pericarp of the nut are firmly coherent and indistinguishable, and the whole is more or less enclosed by that kind of involucre called a *cupule*. The Acorn (*fig.* 377), and the Hazel-nut (*fig.* 378), may be taken as examples. By some botanists the fruit of the Coco-nut palm is called a nut, but this differs in being superior, and in its pericarp presenting a distinction into epicarp, mesocarp, and endocarp. Such a fruit is better described as *nut-like*. By others again, the Coco-nut is described as a drupe with a fibrous mesocarp.

b. WITH A DRY DEHISCENT PERICARP.

1. *Diplotegia.* — This is the only kind of inferior fruit which presents a dry dehiscent pericarp. It has already been stated under the head of Capsule, that the diplotegia differs in nothing from it, except in being inferior. The *Campanula* is an example of this fruit (*figs.* 671 and 672). It may open either by pores, or valves, like the ordinary capsule.

c. WITH A FLESHY INDEHISCENT PERICARP.

1. *The Bacca or Berry* is an inferior, indehiscent, one or more celled, many-seeded, pulpy fruit (*figs.* 698 and 699). The pulp

Fig. 698.

Fig. 699.

Fig. 700.

Fig. 698. Transverse section of a berry of the Gooseberry (*Ribes Grossularia*). *pl.* Placentas. *s p.* Seeds imbedded in pulp.——*Fig.* 699. Clusters of berries of the Red Currant (*Ribes rubrum*).——*Fig.* 700. Nuculanium or fruit of the Vine (*Vitis vinifera*).

is formed from the placentas, which are parietal *pl*, and have the seeds *s* at first attached to them (*fig.* 698); but the latter become

ultimately separated and lie loose in the pulp *p*. Examples may be found in the Gooseberry and Currant. We have already stated, that the fruit of the Grape is called a Nuculanium (*fig.* 700), and that it differs in nothing essential from the berry, except in being superior. The name *baccate* or *berried* is commonly applied by many botanists to any fruit of a pulpy nature.

2. *The Pepo* is an inferior, one or spuriously three-celled, many-seeded, fleshy or pulpy fruit (*fig.* 701). The seeds are attached to parietal placentas, and are imbedded in pulp, but they never become loose as is the case in the berry; and hence this fruit is readily distinguished from it. There has been much discussion with regard to the nature of the pepo. By some botanists the placentas are considered as axile, and the fruit normally three-celled, as it is formed of three carpels; while by others the placentas are regarded as parietal, and the fruit normally one-celled, as defined above. Those who adopt the first view believe that each placenta sends outwards a process towards the walls of the fruit, and that these processes ultimately reach the walls and then become bent inwards and bear the seeds on the curved portions; if these processes remain, the fruit is three-celled, if, on the contrary, they become absorbed, it is only one-celled, and the placentas are spuriously parietal. According to the view here adopted, the placentas which are parietal, send processes inwards which meet in the centre, and thus render the fruit spuriously three-celled; or, if these are afterwards obliterated, or imperfectly formed, it is one-celled. This fruit is illustrated by the Melon, Gourd, Cucumber, Elaterium, and other Cucurbitaceæ. The fruit of the Papaw-Tree resembles a pepo generally, except in being superior.

Fig. 701.

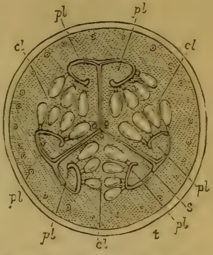


Fig. 701. Transverse section of the fruit or pepo of the Melon. *cl, cl, cl.* Carpels. *s.* Processes proceeding from the centre towards the circumference, *t*, and terminated by curved placentas, *pl, pl, pl, pl, pl, pl.*

3. *The Pome* is an inferior, indehiscent, two or more celled, few-seeded, fleshy fruit; the endocarp of which is papery, cartilaginous, or bony, and surrounded by a fleshy mass consisting of mesocarp and epicarp, which is generally considered to be formed by the cohesion of the general parenchyma of the ovary with the tube of the calyx. Examples may be seen in the Apple (*fig.* 702), Pear, Quince (*fig.* 459), Medlar, Hawthorn, &c. By some botanists, the outer fleshy portion is considered as an enlarged concave receptacle like that of the Rose (*fig.* 439), and the bony or cartilaginous cells are then regarded as distinct carpels, the walls of which are formed of the three layers of the pericarp completely united and indistinguishable.

4. *The Balausta* is an inferior, many-celled, many-seeded, indehiscent fruit, with a tough rind. It is formed of two rows

Fig. 702.

Fig. 703.

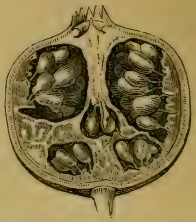


Fig. 702. Vertical section of the pome or fruit of the Apple (*Pyrus Malus*).—— *Fig.* 703. Vertical section of the balausta or fruit of the Pomegranate.

of carpels placed above each other, and surrounded by the calyx, and the seeds are attached irregularly to the walls or centre. The Pomegranate fruit (*fig.* 703) is the only example.

2. Fruits formed by the combination of several Flowers.

These fruits are commonly termed *Anthocarpous*, as they consist not only of the carpels of several flowers united, but also usually of the bracts and floral envelopes in combination with them. They have been also called *Multiple*, *Aggregate*, or *Collective fruits*, and the two former terms have been also applied in a different sense, as mentioned under the head of *Apocarpous fruits*.

1. *The Cone* is a collective, more or less elongated fruit, composed of a number of indurated scales, each of which bears one or more naked seeds (*fig.* 709). This fruit is seen in the Fir (*fig.* 269), Larch, Spruce (*fig.* 397), Araucaria, and many other plants of the order Coniferæ; which derives its name from this circumstance. All plants of the Cycas family also which possess fruit, have one of a similar structure. There are two views as to the nature of the indurated scales: by some botanists they are regarded as carpels spread open, by others as bracts. They certainly more resemble the latter organs in appearance, as they never present any trace of style or stigma on their surface.

2. *The Galbulus.*—This fruit is but a modification of the Cone; differing only in being more or less rounded in form instead of somewhat conical, and having the heads of the scales much enlarged. It is seen in the Cypress (*fig.* 705), and in the Juniper (*fig.* 704). In the latter the scales become fleshy, and are united together into one mass, so that it somewhat resembles at first

sight a berry, but its nature is at once seen by examining the apex, when three radiating lines will be observed corresponding

Fig. 704. *Fig.* 705. *Fig.* 706.

Fig. 704. Galbulus or fruit of Juniper (*Juniperus communis*).——*Fig.* 705. Galbulus or fruit of the Cypress (*Cupressus sempervirens*).——*Fig.* 706. Sphalerocarpium or fruit of the Yew (*Taxus baccata*), surrounded by bracts at the base.

to the three scales of which the fruit has been formed, and which are here but imperfectly united.

No other kind of fruits except the Cone and Galbulus are found in the Coniferæ and Cycadaceæ.

In the Yew however (*Taxus*) (*fig.* 706), the so-called fruit consists simply of a naked seed, nearly enclosed in a succulent cup-shaped mass, which is a development from the outer coat (*primine*) of the ovule. This fruit has been called the *Sphalerocarpium.* Properly speaking, it does not belong to the class of Collective fruits at all, as it is formed of but a single flower. We have placed it here following Dr. Lindley's arrangement, and because of its similarity in structure to the two preceding fruits.

The Cone must be carefully distinguished from Cone-like fruits, such as the *Magnolia* (*fig.* 652), *Liriodendron* (*fig.* 589), &c. The latter are not collective fruits at all, but they consist of the aggregated carpels of a single flower, placed upon an elongated thalamus.

3. *The Strobilus* or *Strobile.*—The fruit of the Hop (*Humulus Lupulus*) (*fig.* 398) is by some botanists considered as a kind of Cone with membranous scales, to which the name of *Strobilus* or *Strobile* has been given; but this fruit differs essentially from the cone, in having its seed distinctly enclosed in an ovary placed at the base of each scale. We distinguish this fruit, therefore, as a distinct kind, under the above name. It should be also noticed that the term Strobilus is frequently employed synonymous with Cone.

4. *The Sorosis* is a collective fruit, formed of a number of separate flowers firmly coherent into a fleshy or pulpy mass with the thalamus upon which they are situated. Examples of this may be seen in the Pine-apple (*fig.* 706, 2), where each square

portion represents a flower; and the whole surmounted by a crown of empty bracts. The Bread-fruit and Jack-fruit are other examples of the porosis. The Bread-fruit has been already alluded to, as affording an instance of a fruit which grows most freely and becomes best adapted for food in propor-

Fig. 706, 2.

Fig. 707.

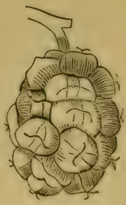


Fig. 708.

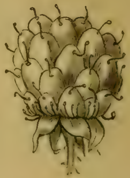


Fig. 706, 2. Pine-apple fruit (*Sorosis*), surmounted by a crown of empty bracts.——*Fig.* 707. Sorosis or fruit of the Mulberry (*Morus nigra*).——*Fig.* 708. Fruit of the Raspberry (*Rubus Idæus*), called an etærio.

tion to the absence of seeds, and it thus presents a well-marked example of a departure from the ordinary character and condition of fruits. The Mulberry (*fig.* 707) may be also cited as another well-known fruit, which presents an example of a sorosis. At first sight, the Mulberry appears to resemble the Raspberry (*fig.* 708), Blackberry, and other fruits derived from the genus *Rubus* to which they belong, but in origin and structure the latter are totally different. Thus as already noticed in speaking of the Etærio, the Raspberry and other fruits derived from the same genus, consist of a number of drupes or fleshy achænia crowded together upon a dry thalamus, and are all the produce of a single flower; but in the Mulberry, on the contrary, each rounded portion of which the fruit is made up is derived from a flower, the calyx of which has become succulent and united to the ovary; the combination of a number of flowers in this case therefore forms the fruit, while in the Raspberry, &c. it is formed but by one flower.

5. *The Syconus* is a collective fruit, formed of an enlarged and more or less succulent receptacle, which bears a number of separate flowers. The Fig (*fig.* 383) is an example of a

syconus; in the Fig, the flowers are almost entirely enclosed by the enlarged hollow pear-shaped receptacle, and what are vulgarly called seeds are in reality one-seeded fruits resembling achænia. The *Dorstenia* (*fig.* 384) is another example of the syconus, although it differs a good deal from the Fig in its general appearance; thus the receptacle is less succulent, and only slightly concave, except at its margins, so that the separate seed-vessels are here readily observed.

All the more important fruits that have been named and described by botanists, have now been alluded to; but in practice only a few are in common use — such as the Legume, Drupe, Achænium, Follicle, Caryopsis, Siliqua, Silicula, Capsule, Nut, Pome, Pepo, Berry, and Cone. This has arisen, partly from the same names having been given by different botanists to totally different kinds of fruits; and partly from botanists in many cases, preferring to describe a particular fruit according to the special characters it presents. It is, however, much to be regretted, that a comprehensive arrangement of accurately named and well-defined fruits should not be generally adopted, as it cannot be doubted, if such were the case, that it would be attended with much advantage, and save a great deal of unnecessary description and repetition.

Section 6.—The Ovule and Seed.

Having now described the nature, structure, and general characters of the pistil, in its unimpregnated and impregnated or fertilized state, we pass to the description of the Ovules and Seeds, which are contained within those two organs respectively, and which bear the same relation to each other as regards their condition, as the pistil does to the fruit,— that is to say, the ovule is an unimpregnated body, the seed an impregnated or fertilized ovule.

1. THE OVULE.

The ovule is a small, rounded or oval, pulpy body, borne by the placenta, and which when impregnated becomes a seed. It is either attached directly to the placenta, in which case it is said to be *sessile* (*figs.* 429, *o* and 618, *g*), or, indirectly, by a stalk called the *funiculus*, *podosperm*, or *umbilical cord* (*figs.* 653, *f*, and 600, *ov*), when it is described as stalked. The point of attachment of the ovule to the placenta if sessile, or to the funiculus when stalked, is termed the *hilum* or *umbilicus*. These terms are applied to the seed in the same sense as to the ovule.

The ovule has been compared to a bud, and has been called the *seed-bud* by Schleiden and others. In parietal and axile placentation, it may be regarded as analogous to a bud which is

formed on the margin of a leaf, as in *Bryophyllum calycinum* (*fig.* 195) and *Malaxis paludosa* (*fig.* 196); or if on a free central placenta, as in Primrose, to a bud formed on the axis. Henslow has described a monstrosity of the Mignonette, in which the ovules were transformed into leaves, and Lindley has also, in his *Elements of Botany*, figured a similar monstrous development of the ovules in *Aquilegia*.

The ovule is in most cases enclosed in the cavity of the ovary; but all plants of the orders Coniferæ and Cycadaceæ are exceptions to this. Thus in the latter order, the ovules are situated on the margins of leaves in a peculiarly metamorphosed condition, and in the former, at the base of indurated bracts or open carpellary leaves (*fig.* 709). In both the above cases, as there is no ovary, there is no style or stigma, and the ovules therefore, instead of being fertilized by pollen applied through the stigma, as is commonly the case, are exposed and fertilized by its direct application. Such ovules are termed *naked.* The seeds of such plants are also necessarily naked, and hence they have been called *Gymnospermous Plants*, that is, — plants with naked seeds; while those plants in which the ovules and seeds are distinctly enclosed in an ovary, have been called *Angiospermous Plants.* It should be noticed however, that there are some plants in which the seeds become partially naked in the course of development, as in the Mignonette (*fig.* 650), *Leontice*, *Cuphea*, &c., in which cases they are sometimes termed *seminude.* The only instances however, of plants possessing naked ovules from their earliest condition, are in the two orders above alluded to; this is a circumstance to be particularly noticed, as such a character is always attended with important structural and physiological differences.

Fig. 709.

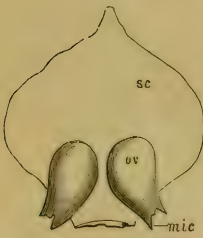


Fig. 709. Bract or carpellary leaf, *sc*, of a species of *Pinus*, bearing two naked ovules, *ov*, at its base; *mic*, micropyle of the ovule.

Number, and position of the Ovules. — The number of ovules in the ovary, or in each of its cells, varies. Thus in the Polygonaceæ (*fig.* 710), Compositæ, Thymelaceæ, Valerianaceæ, Dipsacaceæ, &c., the ovary contains but a solitary ovule; in the Rubiaceæ, Umbelliferæ, Araliaceæ, &c., there is but one ovule in each cell. When there is more than one ovule in the ovary, or in each of its loculi or cells, the number may be either uniform and easily counted, when they are said to be *definite*, as in *Æsculus* (*fig.* 714), &c.,—and the ovary or cell is then described as *biovulate*, *triovulate*, *quadriovulate*, *quinqueovulate*, &c.,

— or, they may be very numerous, when it is said to be *multi-ovulate* or *indefinite*, as in *Viola* (*fig.* 429).

The position of the ovules with regard to the cavity in which they are placed is also liable to vary. Thus when there is but one ovule, this may arise at the bottom of the ovary and be directed towards the summit, as in Compositæ, Polygonaceæ (*fig.* 710), Rubiaceæ, &c., when it is said to be *erect;* or it may be inserted at the summit of the ovary and be turned downwards, as in the Valerianaceæ, and *Hippuris* (*fig.* 711),

Fig. 710.

Fig. 711.

Fig. 712.

Fig. 713.

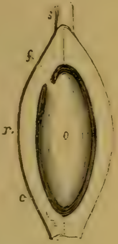


Fig. 710. Vertical section of the ovary of a species of Rumex (*Polygonaceæ*). *p.* Enlarged calyx surrounding the ovary. The ovary contains a single, erect, orthotropous ovule. The embryo is inverted or antitropous.——*Fig.* 711. A carpel of the Mare's Tail (*Hippuris vulgaris*). *o.* Ovule, which is inverse or pendulous, and anatropous. *s.* Base of the style. *f.* Funiculus. *r.* Raphe. *c.* Chalaza. From Jussieu.——*Fig.* 712. A carpel of the Pellitory (*Parietaria officinalis*), with a single ascending ovule. The letters have the same references as in the last figure. From Jussieu.——*Fig.* 713. A carpel of the Mezereon (*Daphne Mezereum*), containing a solitary suspended ovule. The letters refer as before.

&c., in which case it is *inverse* or *pendulous;* or if it is attached a little above the base, and is directed obliquely upwards, as in *Parietaria* (*fig.* 712), it is *ascending;* or if, on the contrary, it arises a little below the summit, and is directed obliquely downwards, as in the Mezereon (*fig.* 713), Apricot, it is said to be *suspended;* if from the side of the ovary, without turning upwards or downwards, as in *Crassula*, it is *horizontal* or *peltate.* In some plants, as in *Armeria* (*fig.* 622), the ovule is suspended from the end of a long funiculus arising from the base of the ovary ; such an ovule is frequently termed *reclinate.*

In the above cases the position of the ovule is in general constant, and hence this character is frequently of much importance in discriminating genera and natural orders. Thus in the Compositæ, the solitary ovule is always erect ; while in the allied orders, the Valerianaceæ and Dipsacaceæ, it is suspended, or pendulous ; — the latter terms are frequently confounded by botanists. In the Polygonaceæ and the Rubiaceæ also, the ovule is always solitary and erect ; in the Thymelaceæ

it is suspended. In other natural orders we find the position varying in different genera, although generally constant in the same; thus in the Rosaceæ, the genera *Geum*, *Alchemilla*, &c., have an ascending ovule, while those of *Poterium*, *Sanguisorba*, &c., have it suspended, and in *Potentilla*, both ascending and suspended ovules are found. In the Ranunculaceæ also, we find the ovule varying in like manner as regards its position.

We will now consider the position of the ovules when their number is more than one. Thus when the ovary or loculus has two ovules (*biovulate*), these may be either placed side by side at the same level, and have the same direction, as in *Nuttalia*. when they are said to be *collateral;* or they may be placed at different heights, and then either follow the same direction, when they are *superposed*, or one ovule may be ascending, and the other suspended, as in *Æsculus* (*fig.* 714). The position of the ovules also, in those cases where they are in definite numbers, is usually constant and regular, and similar terms are employed. When the number of ovules in the ovary or loculus is indefinite, the relations are less constant, and depend in a great measure upon the shape of the loculus, and the size of the placentas. Thus in the long ovaries of many of the Leguminosæ (*fig.* 653) and Cruciferæ (*fig.* 600), the ovules are superposed, and by not crowding each other they will all be turned in the same direction; while, on the contrary, if the ovules are numerous, and developed in a small space, they will necessarily crowd each other, and acquire irregular forms and varying positions according to the direction of the pressure. In describing these varying positions the same terms are used, as those referred to when speaking of the relations of the solitary ovule. These terms are also applied in the same sense to the relations of the seed in the pericarp.

Fig. 714.

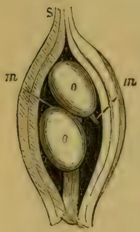


Fig. 714. A loculus of the ovary of a species of *Æsculus* containing two ovules, one of which is ascending and the other suspended; *m* micropyle. The other letters refer as before. From Jussieu.

Formation and Structure of the Ovule. — The ovule appears at first, as a little roundish cellular projection on the placenta; this gradually enlarges and acquires ultimately, a more or less ovate or somewhat conical form; this body is termed the *nucleus* (*fig.* 715). It is at first perfectly uniform in texture and appearance, presenting no cavity as distinct from those of the ordinary parenchymatous cells of which it is composed, and having no integuments. As development proceeds a cavity is formed at or near the apex of the nucleus (*fig.* 716), in which the embryo or future plant is developed; hence this is called the *embryo-sac* or *sac of the amnios.* In rare cases, as in

the Mistletoe, two or three embryo-sacs are formed. This sac is either formed by a simple hollowing out of the nucleus, and the consequent formation of a cavity of variable form and size; or it is produced (as appears to be generally the case) by the special development of one of its cells, and which as it continues to increase in size, presses upon the surrounding cells, and thus causes their more or less complete absorption. This sac sometimes causes the almost entire absorption of the nucleus, and even projects beyond it, either through the opening in its coats afterwards to be described, called the *micropyle*, or through its sides in various directions, by which one or more saccate processes are formed. The embryo-sac is surrounded by a thin layer of cells, which has received the name of *tercine*. The sac contains at first, an abundance of protoplasmic matter, in which are developed towards, or at the period of fertilization, endosperm cells and germinal vesicles. The formation of these will be alluded to hereafter, under the two heads of Albumen and Fertilization. The protoplasmic semi-fluid matter is by some called the *liquor amnios*. Some ovules, as those of the Mistletoe (*fig* 715), &c. consist simply of the nucleus and embryo-sac as above described, in which case the nucleus is termed *naked*. In almost all plants, however, the nucleus becomes enclosed in one or two coats: thus in the Walnut, there is but one coat, and that appears at first as a little circular process around its base, this gradually increases in size, and by growing upwards, ultimately forms a sheath or cellular coat to the nucleus, which it entirely closes except at the apex, where a small opening may be always observed (*fig.* 717). The coat thus formed, where there is but one, is called the *integumentum simplex*, *s*, and the orifice, *end*, at the apex of the nucleus, *n*, is termed the *micropyle* or *foramen*. Besides the Walnut, there is only one coat formed in the Compositæ, Campanulaceæ, Lobeliaceæ, &c.

Fig. 715.

Fig. 716.

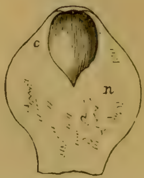


Fig. 715. Undivided ovule of the Mistletoe (*Viscum album*), consisting of a naked nucleus.——*Fig.* 716. The same ovule cut vertically to show the embryo-sac, *c*. *n*. Nucleus.

In most plants, however, the ovule has two coats, in which case we observe two circular or annular processes around the base of the nucleus, the inner one being first developed, and consequently projecting at this time beyond the outer. These processes continue to grow upwards as before described, until they also ultimately form two sheaths or coats, which entirely

enclose the nucleus except at its apex (*fig.* 718). The inner coat is at first seen to project beyond the outer, but the latter ultimately reaches and encloses it. The inner coat is termed the *secundine*, *s*, and the outer the *primine*, *p*. Schleiden and some other botanists call the secundine, the *integumentum primum internum*, and the primine, the *integumentum secundum externum*; which on the whole are the best terms, as they indicate, not only the order of development of the coats, but also their relative position. Other German botanists, again, also following the order of development, term the inner coat *primine*, and the outer *secundine*, thus reversing the names as commonly applied in this country. The orifice left at the apex of the nucleus, as in the former instance where only one coat was present, is called the *foramen* or *micropyle*. The openings in the two coats commonly correspond to each other, but it is sometimes found convenient to distinguish these by distinct names; thus that of the outer, is called the *exostome*, *ex*, that of the inner, *endostome*, *end*. The nucleus and its coat or coats are intimately connected at one point by a cellulo-vascular cord or layer, called the *chalaza* (*figs.* 719 and 720, *ch*); at the other parts of the ovule they are more or less distinct. This chalaza is the point where the vessels pass from the placenta or funiculus into the ovule for the purpose of affording nourishment to it; it is generally indicated by being coloured, and of a denser texture than the tissue by which it is surrounded (*figs.* 719 and 720). The chalaza is by some considered as the organic base of the ovule, and the micropyle as the organic apex; but it is better to speak of the hilum as the organic base of the ovule, and the chalaza as the base of the nucleus. Through the micropyle or organic apex of the ovule, the influence of the pollen is conveyed to the embryo-sac, as will be hereafter fully described

Fig. 717.

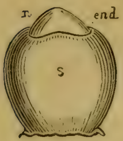


Fig. 718.

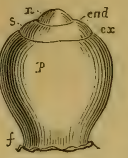


Fig. 717. Ovule of the Walnut (*Juglans regia*). *n*. Nucleus. *s*. Coat covering the nucleus, except at the foramen, *end*.——*Fig.* 718. Ovule of species of *Polygonum*. *f* End of ovule attached to placenta. *p*. Primine. *s*. Secundine. *ex*. Exostome. *end*. Endostome.

Relation of the Hilum, Chalaza, and Micropyle to each other.—When an ovule is first developed, the point of union of its coats and nucleus, called the chalaza, is at the base or hilum, close to the placenta; in which case, a straight line would pass from the micropyle through the axes of the nucleus and its coats to the hilum. In rare instances this relation of parts is preserved throughout its development, as in the Polygonaceæ (*fig.* 719), &c.; such ovules are termed *orthotropous*

or *atropous.* In such an ovule therefore, the micropyle, *m*, would be situated at the geometrical apex, or at the end farthest removed from the hilum, and the organic and geometrical apices would consequently correspond; while the chalaza, *ch*, would be situated at the base of the ovule or hilum.

It generally happens that the ovule instead of being straight as in the above instance, becomes more or less curved, or even altogether inverted. Thus in the Wallflower (*fig.* 720), and other plants, of the order to which it belongs, as well as in the Caryophyllaceæ, &c., the apex of the ovule, becomes gradually turned downwards towards the base, and is ultimately placed close to it, so that the whole ovule is bent upon itself, and a line drawn from the micropyle, *mic*, through the axes of the nucleus, *n*, and its coats would describe a curve; hence such ovules are called *campylotropous* or *curved.* In these ovules, the chalaza, *ch*, and hilum correspond as in orthotropous ones, but the micropyle, *mic*, instead of being at the geometrical apex of the ovule, is brought down close to the hilum or base. The progressive development of the *campylotropous* ovule is well seen in the Mallow, as represented in *fig.* 722. This kind of ovule appears to be formed by one side developing more extensively than the other, by which the micropyle is pushed round to the base.

Fig. 719.

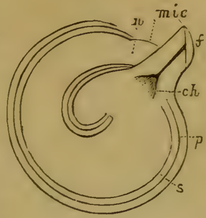


Fig. 720.

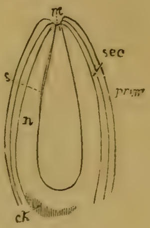


Fig. 719. Orthotropous ovule of *Polygonum*. *ch.* Chalaza. *prim.* Primine. *sec.* Secundine. *n.* Nucleus. *s.* Embryo-sac. *m* Micropyle.——*Fig.* 720. Campylotropous ovule of Wallflower. *f.* Funiculus. *ch.* Chalaza. *p.* Primine. *s.* Secundine. *n.* Nucleus. *mic.* Micropyle.

In a third class of ovules the relative position of parts is exactly the reverse of that of orthotropous ones — hence such are called *anatropous* or *inverted* ovules. This arises from an excessive development of the coats of the ovule on one side, by which the chalaza (*fig.* 721, *ch*) is removed from the hilum, *h*, or placenta, to the geometrical apex of the ovule; the micropyle, *f*, is at the same time turned towards the hilum, *h*. The gradual development of an anatropous ovule may be well seen in the *Chelidonium.* In anatropous ovules, a connexion is always maintained between the chalaza and the hilum or placenta, by means of a vascular cord or ridge, called the *raphe* (*fig.* 721, *r*), which is generally considered as an elongated funiculus adhe-

rent to the ovule. This raphe or cord of nutritive vessels passing from the placenta, and which by its expansion forms the

Fig. 721.

Fig. 722.

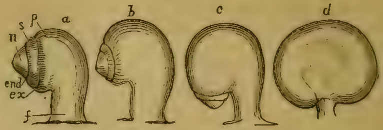


Fig. 721. Anatropous ovule of the Dandelion. *h.* Hilum. *f.* Micropyle or foramen. *n.* Nucleus. *s.* Base of the nucleus. *ch.* Chalaza. *r.* Raphe. —— *Fig.* 722. The campylotropous ovule of the Mallow in its different stages of development. From Maout. In *a* the curvature is commencing, in *b* it is more evident, in *c*, still more evident, and in *d* it is completed. *f.* Funiculus. *p.* Primine. *s.* Secundine. *n.* Nucleus. *ex.* Exostome. *end.* Endostome.

chalaza, is generally situated in anatropous ovules (in which alone it is clearly distinguishable) on the side which is turned towards the placenta. The relative position of the raphe in other ovules has been fully detailed in a paper by Mr. Clark read before the Linnæan Society, but the subject is too complicated to be treated of in this volume. The anatropous ovules are very common; they may be found in the Ranunculus, Apple, Cucumber, &c.

The three kinds of ovules mentioned above, are those only which are commonly distinguished by special names; but there are two others, which appear to be but slight modifications of the anatropous ovule, to which the names of *amphitropous* and *semi - anatropous* have been respectively given. The *amphitropous*, or, as it is also called *heterotropous* or *transverse* ovule, is produced, when the hilum, *f*, is one side of the ovule, and the micropyle, *m*, and chalaza, *ch*. placed transversely to it (*fig.* 724). In this case the hilum is connected to the chalaza

Fig. 723.

Fig. 724.

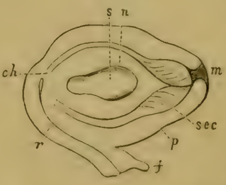


Fig. 723. Longitudinal section of the semi-anatropous ovule of *Meconostigma pinnatifidum*. *f.* Funiculus. *n.* Nucleus. *p.* Primine. *sec.* Secundine. *s.* Embryo-sac. *ch.* Chalaza. *r.* Raphe. *m.* Micropyle. From Schleiden. —— *Fig.* 724. Amphitropous, or transverse ovule of *Lemna trisulca*, divided longitudinally. The letters have the same references as the last. From Schleiden.

by a short raphe, *r*. In the *semi-anatropous* ovule the relative position of the parts is the same (*fig.* 723), but the funiculus *f*, is here parallel to the ovule, instead of being at right angles to it.

The further development of the ovule, and the distinctive characters it presents in Gymnospermous Plants, will be described under the head of EMBRYOGENY.

2. THE SEED.

The seed is the mature or fecundated ovule. It consists essentially of the young plant or embryo, enclosed in integuments, of which there are usually two. Like the ovule, it is either attached directly to the placenta, in which case it is *sessile*, or by means of a stalk, called the *funiculus* (*fig.* 725, *f*); its point of attachment is also termed the *hilum* or *umbilicus*. The position of this hilum may be commonly seen on seeds which have separated from the funiculus or placenta, bythe presence of a scar, or in a difference of colour to the surrounding integuments. The hilum varies much in size, being sometimes very minute, while in other cases it extends for some distance over the surface of the integuments, as in the Horse-Chestnut, *Mucuna*, &c. The centre of the hilum, through which the nourishing vessels pass, has been called the *omphalodium*. The hilum as in the ovule, indicates the base of the seed, while the apex is represented by the chalaza. This chalaza (*fig* 725, *ch*) is generally more evident in the seed than in the ovule, and is frequently of a different colour. It is well seen in the Orange, and commonly in anatropous seeds, in which case also, the raphe may be generally noticed forming a projection on the face of the seed.

Fig. 725.

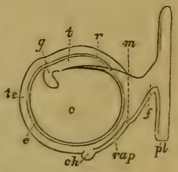


Fig. 725. The seed of a Pea, with its integuments removed on one side. *pl.* Placenta. *f.* Funiculus. *rap.* Raphe. *ch.* Chalaza. *m.* Micropyle. *te.* Testa or episperm. *e.* Endopleura. The part within the endopleura is the nucleus of the seed, and is formed of cotyledons, *c*, gemmule or plumule, *g*, radicle, *r*, and *t* stalk between gemmule and radicle.

The micropyle also, although smaller and less distinct owing to a contraction of the surrounding parts, may be observed on the seed (*fig.* 725, *m*). The detection of this micropyle is of some practical importance, as the radicle, *r*, of the embryo, with a few exceptions, is directed towards it. It should be noticed, that while the micropyle constitutes the organic apex of the ovule, the chalaza indicates that of the seed.

The terms orthotropous, campylotropous, anatropous, &c., are applied to seeds in the same sense as to ovules; consequently the hilum, chalaza, and micropyle, have the same

relations to each other in the seed as in the ovule. Thus the hilum and chalaza are contiguous to each other in an orthotropous seed, and the micropyle is removed to the opposite end; in a campylotropous seed the hilum and chalaza are also near to each other, and the micropyle is brought round so as to approach the hilum; in an anatropous seed the chalaza is removed from the hilum and placed at the other end, while the micropyle and hilum correspond to each other; while in amphitropous and semi-anatropous seeds, the chalaza and micropyle are both removed from the hilum, and placed transversely to it.

Almost all seeds, like ovules, are enclosed in an ovary, the only real exceptions to this law being the Coniferæ and Cycadaceæ, already referred to under the head of the OVULE; and hence the division of Phanerogamic Plants into two classes, called respectively Gymnosperms and Angiosperms; the former including all plants which have naked seeds, the latter those in which they are more or less enclosed in an ovary. The means of distinguishing small fruits from seeds have been also already described. (See p. 299.)

In describing the position of the seed in the ovary, the same terms are used as already mentioned under the head of the OVULE. (See p. 329.) Thus a seed may be *erect*, *inverse* or *pendulous*, *suspended*, *ascending*, &c. The number of seeds contained in the pericarp is also subject to variation, and corresponding terms are used accordingly; thus we say the pericarp is *monospermous*, *bispermous*, *trispermous*, *quadrispermous*, *quinquespermous*, *multispermous*, &c., or one-seeded, two-seeded, three-seeded, four-seeded, five-seeded, many-seeded, &c.

The seed also varies much in form, and, in describing these variations, similar terms are employed to those used in like modifications of the other organs of the plant. Thus, a seed

Fig. 726.

Fig. 727.

Fig. 728.

Fig. 729.

Fig. 726. Rounded seed of the Water-Cress (*Nasturtium officinale*). The testa is reticulated or netted.——*Fig.* 727. Reniform or kidney-shaped seed of the Poppy, with an alveolate or pitted testa.——*Fig.* 728. Obovate seed of the Larkspur (*Delphinium*), the testa of which is marked with ridges and furrows.——*Fig.* 729. Seed of Chickweed (*Stellaria*), the testa of which is tuberculated.

may be rounded, as in the *Nasturtium* (*fig.* 726), ovate, as in *Polygala* (*fig.* 736), oval, as in *Asclepias* (*fig.* 732), obovate,

as in *Delphinium* (*fig.* 728), reniform, as in *Papaver* (*fig.* 727), &c., &c.

Having now alluded to those characters, &c., which the seed possesses in common with the ovule, we pass to the consideration of its special characteristics.

Structure of the Seed. — The seed consists essentially of two parts; namely, of a *Nucleus* or *Kernel* (*fig.* 725) and *Integuments* (*fig.* 725, *te* and *e*), &c. We shall describe each of these parts separately.

1. The Integuments. — There are usually two seed-coats or integuments, which have been variously named by different botanists. The terms most frequently used, are *testa* or *episperm* for the outer coat; *tegmen* or *endopleura* for the inner; and *spermoderm* for the two when spoken of collectively. Some writers, however, use the word testa in a general sense for the two integuments, and call the external one spermoderm. The names first mentioned, are those which will be used in this volume. Some botanists, again, describe a third integument under the name of *sarcoderm;* this layer, however, is commonly and more accurately considered, as but a portion of the outer integument, in which sense we understand it here.

a. *Testa, episperm, or outer integument* (*fig.* 725, *te*). This integument may be either formed of the primine of the ovule only, or by a union of both primine and secundine, which is more frequently the case. The testa is generally composed of ordinary parenchymatous cells, but in some seeds, we have in addition, a coating of hair-like cells containing spiral threads, which are pressed closely to the surface of the seed by a layer of mucilage. (See p. 47.) If such seeds be moistened with water, the mucilage which confines these hair-like cells to the surface of the testa becomes dissolved, by which they are set free, and then branch out in every direction. It frequently happens, also, that the membrane of the cells is ruptured, and the elastic threads which they contain also uncoil, and extend to a considerable distance from the testa. The seed of the *Collomia*, and many other Polemoniaceous Plants, &c., exhibit this curious structure; hence they form beautiful microscopic objects.

Colour, Texture, and Surface of the Testa.—In colour, the testa is generally of a brown or somewhat similar hue, as in the Almond, but it frequently assumes other colours; thus, in some Poppies it is white, in other species of Poppy, in Indian Shot (*Canna*), and Pæony it is blackish, in the Arnatto and Barricarri (*Adenanthera*) it is red, in French Beans and Castor Oil it is beautifully mottled, and in the seeds of different plants various other tints may be observed.

The testa also varies in texture, being either of a soft nature, or fleshy and succulent, or more or less spongy, or membranous,

or coriaceous, or when the interior of its cells is much thickened by secondary deposits it assumes various degrees of hardness, and may become woody, crustaceous, &c.

The surface of the testa, also presents various appearances, and is often furnished with different appendages. Thus it may be smooth or glabrous, as in the *Adenanthera*; or wrinkled, as in *Nigella*; striated, as in Tobacco; marked with ridges and furrows, as in *Delphinium* (*fig.* 728); netted, as in *Nasturtium* (*fig.* 726); alveolate or pitted, as in the Poppy (*fig.* 727); tuberculated, as in Chickweed (*fig.* 729); spiny, as in the Mulberry, &c. The testa of some seeds is also furnished with hairs, which may either cover the entire surface, as in various species of *Gossypium*, where they constitute the material of so much value, called Cotton, and in the Silk-cotton tree (*Bombax*); or they may be confined to certain points of their surface, as in the Willow (*fig.* 733), *Asclepias* (*fig.* 732), *Apocynum*, and *Epilobium* (*fig.* 738); in the latter cases the tufts of hairs thus formed, con-

Fig. 730. *Fig.* 731. *Fig.* 732. *Fig.* 733.

Fig. 730. Seed of a species of *Pinus*, with a winged appendage, *w*. ——*Fig.* 731. Marginate or bordered seed of Sandwort (*Arenaria*). ——*Fig.* 732. Comose oval seed of *Asclepias*. ——*Fig.* 733. Comose seed of a species of Willow.

stitute what is called a *coma*, and the seed is said to be *comose*. The hairs thus found upon the surface of seeds facilitate their dispersion by the wind. Other seeds again, have winged appendages of various kinds, which also render them buoyant and facilitate their dispersion; thus in the Sandwort (*Arenaria*) (*fig.* 731), the testa is prolonged, so as to form a winged margin to the seed, which is then described as *marginate* or *bordered*; in the seeds of the *Pinus* (*fig.* 730), *Catalpa*, *Bignonia*, *Swietenia*, *Moringa*, &c., the testa forms wings, and the seed is *winged*. These winged seeds must be carefully distinguished from samaroid fruits, such as the Ash, Elm, Sycamore, &c., where the wing is an expansion of the pericarp instead of the seed. In like

manner, hairy seeds should be carefully distinguished from the pappose fruits of the Compositæ and Valerianaceæ (*fig.*452), &c., where the hairy expansions proceed from the calyx.

Beneath the testa, the raphe or vascular cord connecting the hilum with the chalaza is found, (this is only clearly distinguishable in anatropous seeds) (*fig.* 734, *r*); its situation is frequently indicated by a projecting ridge on the surface of the seed, as in the Orange, while at other times, it lies in a furrow formed in the substance of the testa, so that the surface of the seed is smooth, and no evidence is afforded externally of its position. The testa is also usually marked externally by a scar indicating the hilum or point by which it is attached to the funiculus or placenta. The micropyle may be also sometimes seen on the surface of the testa, as in the Pea (*fig* 725, *m*), but in those cases where no micropyle can be detected externally, its position can only be ascertained by dissection, when it will be indicated by the termination of the radicle: that is directed (as already noticed) towards the micropyle. In some seeds, as in the Asparagus, the situation of the micropyle is marked by a small hardened point, which separates like a little lid at the period of germination. This has been termed the *embryotegia.*

On removing the testa, we also observe the raphe, which frequently ramifies over the inner coat, and where it terminates, it constitutes the chalaza. The structure and general appearances of these different parts have been already described.

b. *Tegmen, endopleura, or internal membrane* (*figs.* 725, *e*, and 734).—The inner membrane or integument of the seed is essentially parenchymatous like the outer. This coat may be either formed from the tercine only, as is usually the case; or of the latter combined with the embryo-sac; or, in some cases, probably from the secundine of the ovule. This layer appears at times to be altogether wanting, which probably arises from its complete incorporation or adherence to the testa. Sometimes the embryo-sac in the ripe seed remains distinct from the albumen of the nucleus (*fig.* 739), and remains in the form of a bag or sac which envelopes the embryo, as in the Nymphæaceæ, Piperaceæ, and Zingiberaceæ. To this distinct membrane the name of *vitellus* has been given.

Fig. 734.

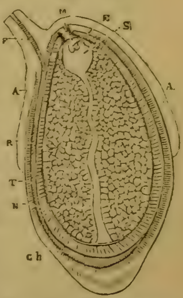


Fig. 734. Young anatropous seed of the White Water-Lily (*Nymphæa alba*) cut vertically. F. Funiculus. A, A. Arillus. T. Integuments of the seed. N. Nucleus. R. Raphe. *ch.* Chalaza. M. Micropyle. *s.* Embryo-sac. *e.* Rudimentary embryo.

The endopleura is generally of a soft and delicate nature, although sometimes of a fleshy character, either entirely or in part. It is usually of a whitish colour, and more or less transparent. This layer is closely applied to the nucleus of the seed, which it accompanies in all its foldings and windings; and in some cases even dips down into the albumen of the nucleus, and thus divides it more or less completely into a number of parts, as in the Nutmeg, Betel-nut (*fig.* 740, *p*), &c.; the albumen is then said to be *ruminated.* (See ALBUMEN, p. 344.)

The testa may either accompany the endopleura in its windings; or, as more frequently happens, especially when the nucleus is curved, the endopleura only follows the nucleus, the testa remaining in an almost even condition.

Arillus. — Besides the two integuments described above, as being usually found in all seeds; we occasionally find on the surface of others, an additional integument, usually of a partial nature (*fig.* 734, A, A), to which the name of *arillus* or *aril* has been given. No trace of this is present in the ovule till after the process of fertilization has taken place. Two forms of the arillus have been described by St. Hilaire and Planchon, which have an entirely different origin, the former being called the *true arillus*, and the latter the *false arillus* or *arillode.* The *true arillus* arises in a somewhat similar manner to the coats of the ovule already described, that is to say, it makes its first appearance around the hilum in the form of an annular process derived from the placenta or funiculus; this gradually proceeds upwards, so as to produce a more or less complete additional covering to the seed, on the outside of the testa. This arillus is well seen in the *Nymphæa* (*fig.* 734, A, A), and *Passiflora.*

The *false arillus* or *arillode*, according to the investigations of St. Hilaire, and the more recent elaborate ones of Dr. Planchon, arises from the micropyle, and seems to be a development or expansion of the exostome, which gradually extends itself over the testa to which it forms a covering, and after thus coating the seed, it may be even bent back again so as to enclose the micropyle. The gradual development of the arillode in the Spindle-tree (*Euonymus*), is well shown in *fig.* 735. In the Nutmeg, the arillode forms a scarlet covering to the testa, which is commonly known under the name of *mace.* Mr. Miers has endeavoured to show, that the arillode in the *Euonymus* is produced from the funiculus rather than from the exostome of the primine, in which case the arillode would necessarily be of the same nature as the arillus.

Caruncles or Strophioles. — These are small irregular protuberances which occur on various parts of the testa. They are always developed, like the arillus and arillode, subsequent to fertilization, and are accordingly not found in the ovule. In

the *Polygala* (*fig.* 736), they are situated at the base or hilum of the seed; in the Asarabacca (*fig.* 737), Chelidonium and

Fig. 735.

Fig. 735. Progressive development of the arillode of *Euonymus*. *a.* Arillode. *f.* Funiculus. 1. represents the youngest seed; 2 and 3. the progressive development of the arillode; 4. the oldest and fully developed seed.

Violet on the side, in a line with the raphe; while in the Spurge, they are placed at the exostome. Some writers consider these caruncles as forms of the aril, of which they then distinguish four varieties, namely:—1. The *true arillus*, as in *Nymphæa* (*fig.* 734, A, A); 2. The *arillode* or *micropylar arillus*, as in *Euonymus* (*fig.* 735, *a*); 3. The *raphian arillus*, as in *Asarum* (*fig.* 737); and 4. The *chalazal arillus*, as in *Epilobium*

Fig. 736.

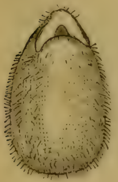


Fig. 737.

Fig. 738.

Fig. 736. Ovate seed of Milkwort (*Polygala*), with a caruncula at its base or hilum.——*Fig.* 737. Seed of Asarabacca (*Asarum*), with a caruncula on the side, called by some a raphian arillus.——*Fig.* 738. Comose seed of *Epilobium*. The tuft of hairy processes is sometimes called a chalazal arillus.

(*fig.* 738), where the tuft of hairs at one end of the seed is so regarded. Other writers again, partially adopt these views, and define the caruncles as little protuberances occurring upon the seed, but originating independently of the funiculus or micropyle, so that the caruncles of *Polygala* and *Euphorbia*, alluded to above, would come under one of the varieties of arillus, accord-

ing to their respective origins. Other botanists again, instead of using the two terms strophioles and caruncles as synonymous with each other, apply the former term only when they proceed from the hilum, and the latter to those from the micropyle. Altogether, there is a great difference of opinion among botanists, as to the application of the terms caruncles and strophioles; in this country they are more commonly understood in the sense in which we have first defined them.

2. THE NUCLEUS OR KERNEL (*figs.* 725 and 734, N).—The nucleus of the seed corresponds to the same portion of the ovule in a mature condition. In order to understand its structure, we must briefly narrate the changes which the nucleus of the ovule undergoes after the process of fertilization has been effected. We have already stated, that at an early period, a quantity of protoplasmic matter of a semi-fluid nature is deposited in the embryo-sac. In this matter nuclei soon make their appearance; and their formation is succeeded by the development of a number of loose cells; these are first produced upon the walls of the embryo-sac, and their formation extends gradually inwards. A similar development of cells also frequently takes place on the outside of the embryo-sac, and therefore in the nucleus itself, which is in such cases necessarily thickened. These cells, which contain nutritive matters of various kinds, are especially designed for the nourishment of the embryo, which is developed in the sac after the process of fertilization. (See FERTILIZATION.)

The embryo, by absorbing the nourishment by which it is surrounded, begins to enlarge, and in so doing presses upon the parenchymatous cells by which it is enclosed, and thus causes their absorption to a greater or less extent according to the size to which it ultimately attains. In some cases, the embryo continues to develop until it ultimately causes the destruction, not only of the parenchymatous tissue of the embryo-sac, but also of that of the nucleus, in which case it fills the whole interior of the seed, and is coated directly by its proper integuments, which have been just described. At other times, however, the embryo does not develop to any such degree; in which case it is separated from the integuments by a mass of parenchymatous tissue of varying thickness, which may be derived from that of the nucleus itself, or from the nucleus combined with that of the embryo-sac according to the extent to which the embryo has grown; a tissue will thus remain, forming a solid mass round the embryo to which the name of *albumen* has been applied; but as the nature of this substance is different to that called by chemists vegetable albumen, it is better to designate it as the *perisperm*. As this albumen or perisperm is sometimes formed both from the tissue of the nucleus, and that of the embryo-sac also, it has been proposed to call the latter

endosperm, and the former *perisperm*. Both endosperm and perisperm may be seen in the *Nymphæa* (*fig.* 734), &c. The general name of *perisperm* or *albumen* will be principally used here, without reference to its origin. From the above considerations, it will be evident, that the nucleus of the seed may either consist of the embryo alone, as in the Wallflower, the Bean, the Pea (*fig.* 725), which is alone essential to it; or of the embryo enclosed in *albumen* or *perisperm*, as in the Pansy (*fig.* 752, *al*), Oat (*fig.* 687, *a*), *Nymphæa* (*fig.* 739), &c. We have two parts, therefore, to describe as constituents of the nucleus, namely, the albumen or perisperm, and the embryo.

Fig. 739.

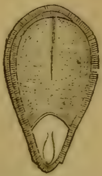


Fig. 739. Vertical section of the seed of the White Water Lily, showing the embryo enclosed in the remains of the embryo-sac or vitellus, and on the outside of this the albumen surrounded by the integuments.

a. *Albumen or Perisperm.*—Those seeds which have the embryo surrounded by a store of nourishing matter, called the albumen, are said to be *albuminous;* while those in which it is absent, are *exalbuminous.* The amount of albumen will in all cases be necessarily in inverse proportion to the size of the embryo. The term albumen will in future be chiefly employed, as it is the one best understood, and so long as we recollect its nature, the adoption of such a name can lead to no confusion.

The cells of the albumen contain various substances, such as starch, oily matters, &c., either separate or combined, and they thus act as reservoirs of nutriment for the use of the embryo during the process of germination. The varying contents of the cells, together with certain differences in the consistence of their walls, cause the albumen to assume different appearances in the ripe seed, and thus it frequently affords good characteristic marks of different seeds. Thus, the albumen is described as *mealy*, *starchy*, or *farinaceous*, when its cells are filled with starch-grains, as in the Oat and other Cereal grains; it is said to be *fleshy*, as in the Barberry and Heart's-ease, when its walls are soft and thick; when its cells contain oil-globules suspended in a viscid mucilage, as in the Poppy and Coco-nut, it is *oily;* when the cells are soft, and chiefly formed of mucilage, as in the Mallow, it is *mucilaginous;* or when the cells are thickened by secondary deposits of a hardened nature, so that they become of a horny consistence, as in the Vegetable Ivory Palm, Coffee, &c., the albumen is described as *horny* or *corneous.* These different kinds of albumen are frequently more or less modified in different seeds by the admixture of one with the other.

Generally speaking the albumen presents a uniform appearance throughout, as in the Vegetable Ivory; but at other

times it is more or less separated into distinct compartments by the folding inwards of the endopleura as already described, (See p. 340); in such cases, the albumen is said to be *ruminated*, as in the Nutmeg, Betel-nut (*fig.* 740, *p*), Papaw, &c.

Fig. 740.

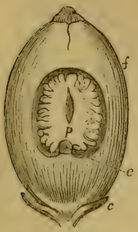


Fig. 740. Vertical section of the fruit of *Areca Catechu*. *c*. perianth. *f*. Pericarp. *p*. Ruminated albumen. *e*. Embryo.

b. *The Embryo* is the rudimentary plant, and is present in all true seeds. The presence of a true embryo is the essential characteristic of the seed of flowering plants; for a spore, as the reproductive body of a flowerless plant is called, has no true embryo, the rudimentary plant being only developed from it after its separation from the parent. The embryo being the rudimentary plant it is necessarily the most important part of the seed, and it contains within it, in an undeveloped state, all the essential parts of which a plant is ultimately composed. Thus we distinguish three parts in the embryo, corresponding to the root, stem, and leaves of the perfect plant; namely, a *radicle*, *plumule* or *gemmule*, and one or more *cotyledons*. These parts may be readily recognised in many seeds; thus in the embryo of the Lime (*fig.* 741), the lower portion, *r*, is the radicle or portion from which the root is developed; the two expanded lobed bodies above, *c*, *c*, are the cotyledons, and between these, the plumule or rudimentary stem is placed. In the Pea, again (*fig.* 160), the two fleshy lobes, *c*, *c*, are the cotyledons, between which there is situated a little bud-like process, the upper part of which is the plumule, *n*, and the lower part, *r*, the radicle. These parts are still better observed when the embryo has begun to develop in the process of germination; thus in figure 161, which represents the French Bean in that condition, *r* is the radicle from which the roots are being given off, the cotyledons are marked *c*, *c*, and the plumule is seen coming off from between the cotyledons, and forming a direct continuation of the axis from which the root is developed below. By some botanists, the point of union of the base of the plumule with the radicle and cotyledons, is called the *caulicule* or *tigelle*; this is generally a mere point, but at other times it forms a short stalk (*figs.* 161 and 725, *t*). Plants which thus possess two cotyledons in their embryo, are called *Dicotyledonous*. But there is another class of plants in which there is commonly but one cotyledon present

Fig. 741.

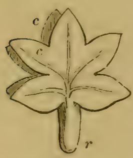


Fig. 741. Embryo of the Lime-tree (*Tilia*). *c*. Cotyledons, with five lobes arranged in a palmate manner. *r*. Radicle.

(*fig.* 742, *c*, and 688, *c*), and which are, accordingly, termed *Monocotyledonous.* Sometimes however, a monocotyledonous embryo has more than one cotyledon, in which case the second cotyledon alternates with the first, instead of being opposite to it, as is invariably the case with the two cotyledons of dicotyledonous plants. By the difference thus presented in the embryos of Flowering Plants, these are divided into two great classes, called respectively *Dicotyledons* and *Monocotyledons.* The spore of Flowerless Plants, having no true embryo, can have no cotyledons, and hence such plants are called *Acotyledonous.* Hence we have primarily two great divisions in the vegetable kingdom: namely, *Cotyledonous* and *Acotyledonous* Plants; the former being again divided into *Monocotyledons* and *Dicotyledons.* The structure of the spore, and other peculiarities connected with Acotyledonous Plants will be described hereafter. We have now, therefore, only to allude to the embryo of Dicotyledons and Monocotyledons. Before doing so, however, we must say a few words as to the development of the embryo.

Fig. 742.

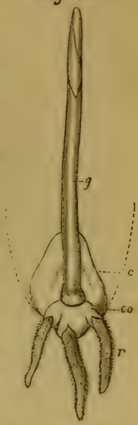


Fig. 742. Germinating embryo of the Oat. *r.* Rootlets coming through sheaths, *co.* *c.* Cotyledon. *g.* Young stem.

Development of the Embryo.—When the process of fertilization has been effected, the embryo-sac, as already noticed, becomes filled with a mass of loose cells destined for the support of the embryo, and which are developed from the protoplasmic matter contained in its interior. The embryo is thus furnished with materials necessary for its growth; and it accordingly commences an active development. At first it is a nucleated cell, called the germinal vesicle, which adheres to the apex of the embryo-sac; this elongates downwards, and its interior is soon divided by transverse partitions, by which it is converted into a string of cells of varying length, which forms the *suspensor* or cord by which the embryo is at first suspended from the embryo-sac. The terminal cell of this body continues to increase in size by the process of cell-division, and soon forms a little rounded, or somewhat oval cellular body at the end of the suspensor (*fig.* 743, 1). This cellular body continuing its growth soon begins to alter in shape, and assume that of the embryo, of which it is the early stage; thus, the upper extremity, in contact with the suspensor, tapers somewhat and forms the radicle, while the lower extremity gradually becomes divided into lobes, which, by increasing in growth, form the cotyledons: the suspensor, during this gradual enlargement, dies away, and

Fig. 743.[1]

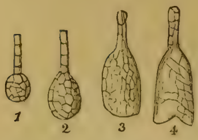


Fig. 743. Progressive development of a dicotyledonous embryo. 1. Earliest stage. 2, 3. Stages of progression. 4. Most developed.

the development of the embryo is completed. The different stages in the development of the embryo are well illustrated in figure 743, 1, 2, 3, 4. From the axil of the cotyledons, the plumule is subsequently developed. The formation of the monocotyledonous embryo is essentially the same, except that the lower end remains undivided. From this mode of development of the parts of the embryo, it must necessarily follow, that the radicle is pointed towards the apex of the nucleus or *micropyle* (*fig.* 734, *m*), and the cotyledonary portion towards the opposite extremity or chalaza.

There are some natural orders which offer an exception to the above process of development. Thus in the Orchidaceæ, Orobanchaceæ, and Balanophoraceæ, the radicle and cotyledons are never clearly distinct from each other, but the embryo appears to be arrested at one of the early stages of its development.

It sometimes happens that more than one embryo is developed in a seed. This is very commonly the case in the Orange, Mistletoe, and especially in Gymnospermous Plants; of these embryos, only one usually becomes perfectly developed. Plants thus producing more than one embryo are said to be *polyembryonic*. With these general remarks upon the development of the embryo, we now proceed to the description of that of Monocotyledonous and Dicotyledonous Plants.

Fig. 744. *Fig.* 745.

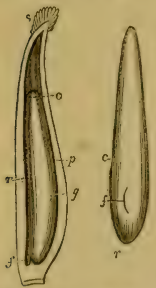


Fig. 744. Vertical section of a carpel of a species of *Triglochin*. *p*. Pericarp. *s*. Stigma. *g*. Seed. *r*. Raphe. *f*. Funiculus. *c*. Chalaza. —— *Fig.* 745. Embryo of *Triglochin*. *r*. Radicle. *f*. Slit corresponding to the gemmule. *c*. Cotyledon. From Jussieu.

a. *The Monocotyledonous Embryo.* — The parts of the monocotyledonous embryo are, in general, by no means so apparent as those of the dicotyledonous. Thus the embryo at first sight externally, usually appears to be a solid undivided body of a cylindrical or somewhat club-shaped form, as in *Triglochin* (*fig.* 745); if this be more carefully examined, however, a little slit, *f*, or chink, will be observed on one side near the base; and if a vertical section be made parallel to this slit, a small conical projection will be noticed, which corresponds to the plumule; and now, by making a horizontal section, the single cotyledon will be noticed to be folded round the plumule, which it had thus almost entirely removed from view, only leaving a little slit corresponding to the union of the margins

of the cotyledon; and which slit thus became an external indication of the presence of the plumule. In fact, the position of the cotyledon thus rolled round the plumule, is analogous to the sheaths of the leaves in most Monocotyledonous Plants, which thus, in a similar manner, enclose the young growing parts of the stem.

In other monocotyledonous embryos the different parts are more manifest; thus in many Grasses, as, for instance, the Oat (*fig.* 687), the cotyledon. *c*, only partially encloses the plumule, *g*, and radicle, *r*; and thus those parts may be readily observed in a hollow space on its surface.

We have already stated, that a monocotyledonous embryo has occasionally more than one cotyledon, in which case the cotyledons are always alternate, and hence such embryos are readily distinguished from those of Dicotyledonous Plants, where they are always opposite to each other if there are but two cotyledons, or whorled (*fig.* 750), when they are more numerous.

The inferior extremity of the radicle is usually rounded (*fig.* 745, *r*); and it is through this point that the roots burst in germination (*fig.* 742, *r*). The radicle is usually much shorter than the cotyledon, and generally thicker and denser in its nature; but in some embryos, on the contrary, it is as long or even longer, in which case, the embryo is termed *macropodous*.

b. *The Dicotyledonous Embryo.* — These embryos vary very much in form: most frequently they are more or less oval, as in the Bean and Almond (*fig.* 746), where the embryo consists of two nearly equal cotyledons, *c*, between which is enclosed a small axis,

Fig. 746.

Fig. 747.

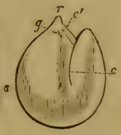


Fig. 748.

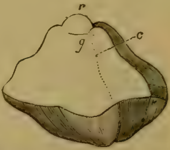


Fig. 749.

Fig. 746. The embryo of the Almond (*Amygdalus communis*) from which one of the cotyledons has been removed. *c*. The cotyledon which has been left. *r*. Radicle. *g*. Gemmule. *t*. Tigelle or caulicule. *c'*. Scar left by the removal of the other cotyledon.——*Fig.* 747. Vertical section of the embryo of a species of *Hiræa*. *c'*. Large cotyledon. *c*. Small cotyledon. *g*. Gemmule. *r*. Radicle.——*Fig.* 748. Vertical section of the embryo of *Carapa Guianensis*, showing the almost complete union of the cotyledons, the line, *c*, only dividing them. *r*. Radicle. *g*. Gemmule.——*Fig.* 749. The embryo of *Pekea butyrosa*. *t*. Large tigelle. *c*. Rudimentary cotyledons.

the upper part of which is the *plumule*, *g*, and the lower the *radicle*, *r*, the point of union between the radicle and cotyledons being called the *caulicule* or *tigelle*, which upon germination appears as a little stalk supporting the cotyledons.

In by far the majority of cases the two cotyledons are nearly of equal size, as in the Pea (*fig.* 160, *c*, *c*), but in some embryos, as in *Trapa*, some *Hiræas*, &c. (*fig.* 747, *cc*), they are very unequal. Again, while the cotyledons usually form the greater part of the embryo, in other instances, as in *Pekea butyrosa* (*fig.* 749, *c*), they form but a small portion. In the *Carapa* (*fig.* 748) again, the two cotyledons become united more or less completely into one body, so that the embryo appears to be monocotyledonous; but it is readily distinguished by the different position of the plumule in the two cases; thus in the monocotyledonous embryo, the plumule is situated just below the surface, but here the plumule, *g*, is in the axis of the cotyledons.

The cotyledons are sometimes altogether absent, as in *Cuscuta*. At other times the number is increased, and this may either occur as an irregular character, or as a regular condition, as in many Coniferæ (*fig.* 750, *c*), where we frequently find six, nine, or even fifteen cotyledons; hence such embryos have been termed *polycotyledonous*. It seems probable that this appearance of a larger number of cotyledons than is usual in Dicotyledonous Plants, arises from the normal number becoming divided down to their bases into segments. In all cases where the number of cotyledons is thus increased, they are arranged in a whorl (*fig.* 750). The cotyledons are usually thick and fleshy, as those of the Bean and Almond (*fig.* 746), in which case they are termed *fleshy*; at other times they are thin and leaf-like, as in the Lime (*fig.* 741), *Euonymus*, &c., when they are said to be *foliaceous*. The foliaceous cotyledons are frequently provided with veins, and stomata may be also sometimes observed on their epidermis; these parts are rarely to be found in fleshy cotyledons. Fleshy cotyledons serve a similar purpose to the albumen, by acting as a reservoir of nutritious matters for the use of the young plant during germination; hence, when the albumen is absent, the cotyledons are generally proportionately increased.

Fig. 750.

Fig. 751.

Fig. 750. Polycotyledonous embryo of a *Pinus* beginning to germinate. *c*. Cotyledons. *r*. Radicle. *t*. Tigelle.——*Fig.* 751. The embryo of *Geranium molle*. *c*. Cotyledons, each of which is furnished with a petiole, *p*. *r*. Radicle.

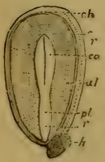
The cotyledons are commonly sessile, and their margins are usually entire, but exceptions occur to both these characters; thus in *Geranium molle* (*fig.* 751), they are petiolate; while in the Lime (*fig.* 741), Walnut, and Geranium, (*fig.* 751) they are lobed.

The cotyledons also vary in their relative positions to each other. Generally they are placed parallel, or face to face, as

in the Almond (*fig.* 746), Pea (*fig.* 160), and Bean already referred to; but they frequently depart widely from such a relation, and assume others, analogous to those already described in speaking of the vernation of leaves and the æstivation of the floral envelopes. Thus each of the cotyledons, may be either *reclinate*, *conduplicate*, *convolute*, or *circinate*. These are the commoner forms, and in such instances both cotyledons are folded or rolled in the same direction, so that they appear to form but one body. In rare cases they are folded in opposite directions, and become *equitant* or *obvolute*. Other still more complicated arrangements sometimes occur.

The position of the radicle in relation to the cotyledons is also liable to much variation. Thus the radicle may follow the same direction as the cotyledons, or a different one. In the former case, if the embryo be straight, the radicle will be more or less continuous in a straight line with the cotyledons, as in the Pansy (*fig.* 752, *r*); if on the contrary the embryo is curved, the radicle will be curved also (*fig.* 753), and sometimes the curvature is so great, that a spiral is formed, as in *Bunias* (*fig.* 754). In the latter case, where the direction of the cotyledons

Fig. 752. *Fig.* 753. *Fig.* 754. *Fig.* 755. *Fig.* 756.





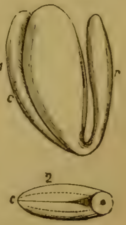


Fig. 752. Vertical section of the seed of the Pansy. *h.* Hilum. *pl.* Embryo with its radicle, *r*, and cotyledons, *co*. *ch.* Chalaza. *al.* Albumen. *r.* Raphe.——*Fig.* 753. Vertical section of the seed of a Poppy, with the embryo slightly curved in the axis of albumen.——*Fig.* 754. Vertical section of the seed of *Bunias*, showing its spiral embryo.——*Fig.* 755. Embryo of the Woad (*Isatis tinctoria*). 1. Undivided. 2. Horizontal section. *c.* Cotyledons. *r.* Radicle.——*Fig.* 756. Embryo of the Wallflower. 1. Undivided. 2. Horizontal section. *r.* Radicle. *c.* Cotyledons.

and radicle is different, the latter may form an acute, obtuse, or right angle to them, or be folded back to such an extent as to lie parallel to the cotyledons: in the latter case, the radicle may be either applied to their margins, as in the Wallflower (*fig.* 756), when the cotyledons are said to be *accumbent*; or against the back of one of them, as in *Isatis* (*fig.* 755), when the cotyledons are *incumbent*. These terms are chiefly used in

reference to Cruciferous Plants (see Cruciferæ), which are commonly arranged according to the manner in which the different parts of the embryo are folded, and their relative positions to each other.

Having now described the general characters of the monocotyledonous and dicotyledonous embryo, we have, in the last place, to allude briefly to the relation which the embryo itself bears to the other parts of the seed, and to the pericarp or loculus in which it is placed.

Relation of the Embryo to the other Parts of the Seed, and to the Fruit. — In the first place with regard to the albumen. It must necessarily happen that when the albumen is present, the size of the embryo will be in the inverse proportion to it; thus in Grasses (*fig.* 687) we have a large deposit of albumen and but a small embryo, while in the Nettle (*fig.* 757), the embryo is large and the albumen small. The embryo may be either external to the albumen, and thus in contact with the integuments, as in Grasses (*fig.* 687), in which case it is described as *external;* or it may be surrounded by the albumen on all sides, except on its radicular extremity, as in the Pansy (*fig.* 752), when it is *internal.* Sometimes the end of the radicle, as in the Coniferæ, becomes united to the albumen, and can no longer be distinguished.

The embryo is said to be *axile* or *axial* when it has the same

Fig. 757.

Fig. 758.

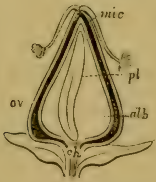


Fig. 759.

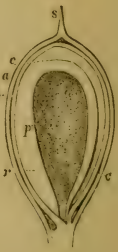


Fig. 760.

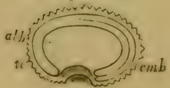


Fig. 757. Vertical section of the achænium of a Nettle, containing a single seed. *t.* Integuments of the seed. *pl.* Placenta. *r.* Radicle. *st.* Stigma. ——*Fig.* 758. Vertical section of the fruit of the Dock (*Rumex*). *ov.* Pericarp. *mic.* Micropyle. *pl.* Embryo towards one side of the albumen, *alb.* *ch.* Chalaza.——*Fig.* 759. Vertical section of the carpel of *Mirabilis Jalapa*, containing one seed. *a.* Pericarp. *s.* Style. *c.* Peripherical embryo with its radicle, *r*, and cotyledons, *c.* *p.* Albumen. *t.* Integuments of the seed. ——*Fig.* 760. Vertical section of the seed of *Lychnis dioica.* *te.* Integuments. *emb.* Embryo on the outside of the albumen, *alb.*

direction as the axis of the seed, as in Heart's-ease (*fig.* 752); when this is not the case, it is *abaxile* or *eccentric*, as in *Rumex* (*fig.* 758). In the latter case, the embryo is frequently altogether on the outside of the albumen, and directly below the integuments, as in *Mirabilis Jalapa* (*fig.* 759), and in *Lychnis* (*fig.* 760), in which case it is described as *peripherical.*

We have already observed, that the radicle is turned towards the micropyle, and the cotyledonary extremity to the chalaza (*fig.* 752). Some apparent exceptions to these relative positions occur in the Euphorbiaceæ, &c., but these are merely accidental deviations, arising from certain trifling irregularities in the course of the development of the parts of the seed.

While the relation of the radicle and cotyledonary portion are thus seen to be generally constant, it must necessarily happen from the varying relations which the hilum bears to the micropyle and chalaza, that the relation of that body to the radicle and cotyledonary portion of the embryo must also vary in like manner. Thus in an orthotropous seed, as *Rumex* (*fig.* 758), the chalaza and hilum coincide with each other, and the radicle is then turned towards the apex of the seed or to the micropyle, and the cotyledonary portion to the chalaza and hilum; in this case the embryo is said to be *antitropous* or inverted. In an anatropous seed, as Pansy, (*fig.* 752), where the micropyle is contiguous to the hilum, and the chalaza at the opposite extremity, the radicle will point towards the hilum or base of the seed, in which case the embryo is said to be *erect* or *homotropous*, as the radicle is considered the base of the embryo, and the chalaza its apex. In a campylotropous seed, where the chalaza and micropyle are both near to the hilum, as in *Lychnis* (*fig.* 760), the two extremities of the embryo, which in such cases is generally peripherical, become also approximated, and it is said to be *amphitropous.* Thus when we wish to know the direction of the embryo, by ascertaining the position of the hilum, chalaza, and micropyle, it is at once evident.

We have now only to explain the different terms which are in use, to express the relations which the embryo bears to the cavity or cell in which it is placed. We have already described the terms used in defining the position of the seed to the same cavity, which we found might be either erect, suspended, pendulous, ascending, or horizontal, in the same sense as previously mentioned when speaking of the ovule. The radicle is said to be *superior* or *ascending*, as in the Nettle (*fig.* 757) and *Rumex* (*fig.* 758), when it is directed towards the apex of the pericarp; *inferior* or *descending* when it points to the base; *centripetal* if turned towards the axis or centre of the pericarp; and *centrifugal* if towards the sides. The above relations of the embryo to the other parts of the seed, and to the pericarp, are sometimes of great practical importance.

Section 7.—The Theoretical Structure, or General Morphology of the Flower.

Having now taken an extended view of the different organs of the flower, we are in a position to examine in detail the theory which has been kept constantly in view in their description, namely, that they are all modifications of one type,—*the leaf.* The germ of this theory originated with Linnæus, but the merit of having first brought it forward in a complete form is due to the poet Goëthe, who, as far back as 1790, published a treatise *On the Metamorphoses of Plants.* The appearance of this treatise at once drew the attention of botanists to this subject, and it is now universally admitted, that all the organs of the flower are formed upon the same plan as the leaf, and that they owe their differences to especial causes connected with the functions which they have severally to perform. Thus the leaf, being designed especially to elaborate nutriment for the support of the plant, has a form, structure, and colour which is adapted for that purpose; while the parts of the flower being designed for the purpose of reproduction, have a structure and appearance which enable them to perform their several functions.

It was formerly said, that the parts of the flower were metamorphosed leaves, but this is stating the question too broadly, because they have never been leaves; they are to be considered only, as *homologous* parts or parts of the same fundamental nature, that is, "constructed of the same elements arranged upon a common plan, and varying in their manner of development, not on account of any original difference in structure, but on account of special, local, and predisposing causes: of this plan the leaf is taken as the type, because it is the organ which is most usually the result of the development of those elements,—is that to which the other organs generally revert, when, from any accidental disturbing cause, they do not sustain, the appearance to which they were originally predisposed,—is that in which we have the most complete type of organisation," * and, moreover,—is that which can always be distinctly traced by insensible gradations of structure into all the other parts.

Having defined the general nature of the doctrine of Morphology, or that doctrine which investigates the various alterations of form, &c., which the different parts of plants undergo in order to adapt them to the several purposes for which they were designed, we proceed to prove that the parts of a flower are homologous with leaves. In doing so, we shall examine the several parts of the flower, both as they exist in a natural condition, and in an abnormal state, commencing with the bract, and then proceeding in a regular manner with the different whorls of the flower, according to their arrangement from without inwards.

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* Lindley's Introduction to Botany.

That the *bract* is closely allied to the leaf, is evident from its structure, form, colour, and from the development of one or more buds in its axil. In order to be perfectly convinced of this analogy, let any one examine the Foxglove, the Lilac, or the Pæony, and then it will be evident that all stages of transition occur between leaves and bracts, so that it will be impossible to doubt their being homologous parts.

That the *sepals* are homologous with leaves, is proved, not only by their colour, &c., but also by the fact, that many flowers exhibit in a natural condition a gradual transition between sepals and bracts, and the latter, as already noticed, are readily referrible to the leaf as a type. Thus in the Camellia, the transition between the sepals and bracts is so marked, that it is almost impossible to say where the latter end and the former begin. In the Marsh Mallow (*fig.* 372), and Strawberry (*fig.* 373) again, the five sepals in the flowers of the two respectively, alternate with five bracts, and the difficulty of distinguishing them is so great, that some botanists call both set of organs by the name of sepals. In many flowers in a natural condition therefore, there is a striking resemblance between sepals and leaves; and this analogy is at once proved to demonstration by the fact, that in monstrous flowers of the Rose, Primrose (*fig.* 761), &c., the sepals are frequently converted into true leaves.

Fig. 761.

Fig. 761. Monstrous Primrose, with the sepals converted into true leaves. From Lindley.

We now pass to the *petals*, and although these in the majority of flowers, are of a different colour to leaves and the parts of the flower which are placed external to them, yet in their flattened character and structure they are essentially the same; and their analogy to leaves is also proved in many natural flowers by the gradual transitions exhibited between them and the sepals. This is remarkably the case in the White Water-Lily (*fig.* 438); also in the *Magnolia*, *Calycanthus*, &c., where the flowers present several whorls of floral envelopes, which so resemble each other in their general appearance and colour, that it is next to impossible to say where the sepals end and the petals begin. In many other cases also, there is no other way of distinguishing between the parts of the calyx and those of the corolla than by their different positions, — the calyx being the outer series, the corolla the inner. The analogy between petals and leaves is still further shown by the fact, that the former are occasionally green, as in a variety of Ranunculus, and in one of *Campanula rapunculoides*; and also from their being

occasionally converted, either entirely or partially, into leaves. We may therefore, consider that the petal, like the sepal and bract, is homologous with a leaf.

The *stamen* is, of all the organs, the one which has the least resemblance to a leaf. In describing the structure of the stamen we have shown, however, that the different parts of the leaf may be clearly recognised in those of the stamen. We find moreover, that in many plants the petals become gradually transformed into stamens. This is remarkably the case in the White Water-Lily (*fig.* 438). In the flowers of this plant the inner series of petals gradually become narrower, and the upper extremity of each exhibits at first two little swellings, which, in those placed still more internal, become true anthers containing pollen. The fact that the stamens can thus be shown to be merely modified petals, and the latter having been already proved to be modified leaves, it must necessarily follow that the stamens are so also. If we now refer to what takes place in many cultivated flowers, we have conclusive evidence at once afforded to us of the leaf-like nature of stamens. Thus in what are called double flowers, the number of petals is principally increased by the conversion of stamens into those organs; hence the number of the latter increases as the former decreases. Thus, if a double Rose be examined, all sorts of transitions may be observed between true petals and stamens. In other cases, the stamens have been actually transformed into true leaves. The stamen is, consequently, also to be considered as a modification of a leaf. As far as the stamens therefore, we have no difficulty in tracing both in the normal and abnormal conditions of the parts of the flower, a regular and gradual transition from the ordinary leaves, thus forming conclusive evidence of their being developed upon a common type with them.

If we now pass to the *pistil*, we find that transition states between the stamen and pistil are unknown in the normal condition of flowers, the difference in the functions performed by them respectively being so opposite, that it necessarily leads to corresponding differences in structure. We must, therefore, look to *monstrosities* or deviations from ordinary structure, for examples of such conditions. Even these are by no means common. Such may, however, be occasionally found in the Houseleek, some species of *Papaver*, &c. In a paper, published by the author in the *Pharmaceutical Journal* for March, 1856, a very remarkable instance of this transition from stamens to carpels was described; it occurred in the *Papaver bracteatum*. In this case, several whorls of bodies, intermediate in their nature between stamens and carpels, were found between the true stamens and pistil. The outer whorls of the intermediate bodies differed from the ordinary stamens, in their colour, in being of a more fleshy nature, and in being enlarged at their upper extremity and inner surface into rudi-

mentary stigmas; in other respects they resembled the stamens, and possessed well-marked anthers containing pollen. The whorls next in succession, gradually lost their anthers, became more fleshy, bore evident stigmas, and on their inner surface which was slightly concave, they had rudimentary ovules. Still more internally, the intermediate bodies, whilst resembling those just described in their general appearance, became more concave on their inner surface, and bore numerous perfect ovules; and within these, the intermediate bodies had their two margins folded completely inwards and united, and thus formed perfect carpels. Such an example as this shows in a striking manner, that the stamens and carpels are formed upon a common type, and hence the latter are, like the former, merely modified leaves. The analogy of the carpel to a leaf is, however, constantly shown in cultivated flowers, even in a more striking manner than the stamen is thus proved to be a modified condition of that organ. Thus in many double flowers, as Buttercups and Roses, the carpels, as well as the stamens, become transformed into petals. It is by no means rare, again, to find the carpels transformed into true leaves in cultivated Roses, &c (*fig.* 641). A similar condition also occurs in the Double Cherry (*fig.* 573), and has been already fully described when speaking of the carpel; in which place we have also shown the analogy of a carpel with a leaf, by tracing its development from a little concave body but slightly differing in appearance from a leaf, up to its mature condition as a closed cavity, containing one or more ovules. We have, therefore, as regards the carpel, the most conclusive evidence of its being formed upon a common type with the leaf, and that it is consequently homologous with it.

Fig. 762.

Fig. 762. A monstrous pear, showing the axis prolonged beyond the fruit, and bearing true leaves.

The carpel, being thus shown to be homologous with a leaf, it must necessarily follow that the fruit is likewise a modified condition of the leaf, since it is formed of one or more carpels in a matured condition.

Further proofs of the homologous nature of the parts of the flower to the leaf, is afforded by the fact, that the floral axis instead of producing flowers, will sometimes bear whorls of true leaves. In other cases the axis becomes prolonged beyond the

flower, as in certain species of *Epacris*, or beyond the fruit (*fig.* 762), and becomes a true branch bearing leaves.

Various other examples might be adduced of the entire transformation of the floral organs into more or less perfect leaves. Thus in the Common White Clover, the parts of the flower are not unfrequently found in a leaf-like state. A similar condition has also been observed in monstrous Strawberry flowers, &c. In fact, no one can walk into a garden, and examine cultivated flowers, without finding numerous instances of transitional states occurring between the different organs of the flower, all of which necessarily go to prove their common origin.

When a sepal becomes a petal, or a petal a stamen, or a stamen a carpel, the changes which take place, are said to be owing to *ascending* or *direct metamorphosis*. But when a carpel becomes a stamen, or a stamen a petal, or a petal a sepal, or if any of these organs become transformed into a leaf, this is called *retrograde* or *descending metamorphosis*.

We have thus proved by the most conclusive facts, that all the organs of the flower are formed upon a common type with the leaf, and differ only in their special development, or, in other words,—that they are homologous parts. Hence a flower-bud is analogous to a leaf-bud, and the flower itself to a branch the internodes of which are but slightly developed, so that all its parts are situated in nearly the same plane; and, as flower-buds are thus analogous to leaf-buds, their parts are also necessarily subject to similar laws of development and arrangement, and hence a knowledge of the latter gives the clue to that of the former. The symmetrical arrangement of the parts of the flower arising from their being homologous parts with the leaves, will be described in the next section, together with the various causes which interfere to prevent or disguise it.

Section 8.—Symmetry of the Flower.

The term symmetry has been variously understood by different authors. As properly applied, a symmetrical flower is one, in which each whorl of organs has an equal number of parts, or where the parts of one whorl are multiples of those of another. Thus in some species of *Crassula* (*fig.* 763), we have a symmetrical flower composed of five sepals, five petals, five stamens, and five carpels; in *Sedum* (*fig.* 764), we have five sepals, five petals, ten stamens in two rows, and five carpels; in the Flax, we have five sepals, five petals, five stamens, and five carpels, each of which is partially divided into two by a spurious dissepiment (*fig.* 603); in the *Circæa* (*fig.* 765), we have two organs in each whorl; in the Rue (*figs.* 564 and 596), we have four or five sepals, four or five

petals, eight or ten stamens, and a four or five-lobed pistil; in the Iris, there are three organs in each whorl. All the above

Fig. 763.

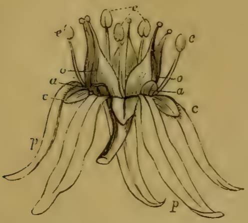


Fig. 764.

Fig. 763. Flower of *Crassula rubens*. *c, c*. Sepals. *p, p*. Petals. *e, e, e*. Stamens. *o, o*. Carpels, at the base ot each of which is seen a scale, *a, a*.——*Fig.* 764. Flower of *Sedum*.

are therefore *symmetrical* flowers. When the number of parts in each whorl does not correspond, or when the parts of a whorl are not multiples of one another, the flower is *unsymmetrical*, as in *Verbena* (*fig.* 391), where the calyx and corolla have five parts in each whorl, and the stamens and pistil only four.

A symmetrical flower, in which the number of parts in each whorl is the same, as in *Crassula* (*fig* 763), is said to be *isomerous*; or when the number is unequal, as in Rue (*figs.* 564 and 596), and *Sedum* (*fig.* 764), the flower is *anisomerous*. The number of parts is indicated by a Greek numeral prefixed to the word *meros*, signifying a part. Thus when there are two parts in the whorls, as in *Circæa* (*fig.* 765), the flower is *dimerous*, and the symmetry is said to be *binary* or *two-membered*: this may be considered as answering to the *distichous* or *two-ranked* arrangement of leaves (*fig.* 267); each whorl forming one cycle composed of two parts the internodes between the several parts not being developed, or to successive pairs of opposite leaves decussating with each other. This arrangement is thus marked 2/. When there are three parts in a whorl, as in the Squill (*fig.* 424), Iris, and Lily, the flower is *trimerous*, and the symmetry is *ternary*, *trigonal*, or *triangular*; it is indicated thus, 3/. This may be regarded, either as answering to the tristichous arrangement of leaves, each whorl forming a cycle of three organs, the internodes between them not being developed; or to successive whorls of three organs in each. When there are four parts in a whorl, as in Rue (*fig.* 564), the flower

Fig. 765.

Fig. 765. Diagram of the flower of *Circæa*.

is *tetramerous*, and the symmetry, which is marked $\sqrt[4]{}$, is *quaternary*, *tetragonal*, or *square*. The successive whorls in such a flower may be compared directly with whorls of leaves, each consisting of four organs; or indirectly with opposite decussating leaves combined in pairs, the internodes not being developed. When there are five parts in a whorl, as in *Crassula rubens* (*fig.* 763), the flower is said to be *pentamerous*, and the symmetry, which is marked thus, $\sqrt[5]{}$, *quinary* or *pentagonal*. Such a flower may be considered as answering to the pentastichous arrangement of leaves with the internodes undeveloped; or to be composed of successive whorls of five leaves, the internodes between each whorl being almost undeveloped, or very short.

Of the above arrangements, the pentamerous is most common among Dicotyledons, although the tetramerous is also by no means rare; while the trimerous is generally found in Monocotyledons. In Acotyledons, when any definite number can be traced in the reproductive organs, it is commonly two, or some multiple of that number.

Although a symmetrical flower, as above described, necessarily infers that the parts in each whorl are equal to, or some multiple of one another, still it is very common for botanists to call a flower symmetrical when the three outer whorls correspond in those particulars, while the parts of the pistil are unequal to them; thus in the *Staphylea pinnata* (*fig.* 766), the three outer whorls are pentamerous, while the pistil is dimerous. The pistil of all the organs of the flower is that which less frequently corresponds in the number of its parts to the other whorls.

Fig. 766.

Fig. 766. Diagram of the flower of *Staphylea pinnata*.

By some writers, again, a flower is said to be symmetrical, when it can be divided into two similar halves, as in Cruciferæ, where there are four sepals, four petals, and six stamens (*figs.* 421 and 422), but the whole are so arranged, that the flower may be separated into two equal parts.

Various other terms are used in describing flowers, which will be best alluded to here, although some have been previously noticed. Thus a flower is said to be *complete*, when the four whorls, — calyx, corolla, stamens, and pistil are present, as in the Rue (*fig.* 564), Iris, &c.; where one or more of the whorls is absent, the flower is *incomplete* (*figs.* 425 and 426). When the parts of each whorl are uniform in size and shape, as in the Rue (*fig.* 564), the flower is *regular*; under other circumstances, it is *irregular*, as in the Pea (*fig.* 463). In a normal arrangement of the parts of the flower, the

successive whorls alternate with each other, as shown in figures 763 and 765; thus here, the sepals alternate with the petals, the petals with the stamens, and the stamens with the carpels or parts of the pistil.

A perfectly normal and typical flower should possess a calyx, corolla, stamens, and carpels, each of which should be so arranged as to form but a single circle of parts; the different whorls should consist of an equal number of members; the parts of successive whorls should alternate with one another; and the organs of each whorl should be uniform in size and shape, and distinct from each other and from the surrounding whorls. This normal and typical flower is, however, liable to various alterations, arising from several disturbing causes, which modify and disguise one or more of the above typical characters. Some of these disturbing causes have been already alluded to in the description of the different organs of the flower, but it will be necessary for us to investigate them more fully here, and classify for systematic study. All the more important deviations of the flower from its normal character, may be arranged under the following heads:—

1st. The adhesion or union of the parts of the same whorl; or those of different whorls.

2nd. The addition of one or more entire whorls in one or more of the floral circles; or increase in the number of parts, which is due to the multiplication by division of any or all of the organs of a whorl.

3rd. The suppression or abortion of one or more of the floral whorls; or of some parts of a whorl.

4th. Irregularity produced by unequal growth; or unequal union of the members of the same whorl; or to abnormal development of the thalamus.

That part of Botany which has for its object the investigation of the various deviations from normal structure, both in the flower and other parts of the plant, is called *Teratology*.

We shall describe the above causes of deviation in the order in which they are placed above.

1. The changes due to union or adhesion of parts.—We divide these into two divisions: namely, the union of the members of the same whorl; and the adhesion of the different whorls; the first is frequently termed *coalescence*, and the latter *adnation*.

a. *Coalescence.*—This is of very common occurrence in the members of the different whorls of the flower. Thus it occurs in the calyx, when it becomes *monosepalous*; in the corolla, when it is *monopetalous*; in the filaments, when it gives rise to *monadelphous*, *diadelphous*, and *polyadelphous* stamens; in the anthers, when they are *syngenesious*; and in the pistil, when the carpels are *syncarpous*. All these modifications have been fully described under their respective heads.

b. *Adnation* or *adhesion* of the different whorls is also, by no means uncommon. Thus the calyx may be united to the corolla, or to the stamens, or with both; or all these whorls may be united to the ovary. These different adhesions have been already explained, under the terms *perigynous*, *epigynous*, and *superior* calyx. Again, the stamens may be united separately to the corolla, when they are said to be *epipetalous*, or to the pistil (*gynandrous*). All the changes due to union or adhesion have been fully described in treating of the different whorls of the flower.

2. Addition or multiplication of parts.—This may be also considered under two heads: — 1st. the addition of one or more entire whorls; and secondly, the increase in the number of parts, which is due to the multiplication by division of any or all of the organs of a whorl. The former is commonly termed *augmentation*, the latter *chorisis*, *deduplication*, or *unlining*.

a. *Augmentation.*—The increase in the number of whorls may occur in one or more of the floral circles. Thus the Barberry, (*fig.* 767) has two whorls of sepals, two of petals, and two of stamens; in this flower, therefore, we have an addition of one whorl of organs to each of the three external floral circles. In the Poppy, we have a number of additional whorls of stamens (*fig.* 769). In the Magnolia family generally, the increase is chiefly remarkable in the carpels (*fig.* 589, *c*). In *Nymphæa* (*fig.* 768), the petals and stamens are greatly increased in num-

Fig. 767.

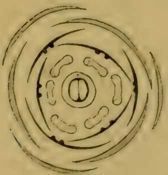


Fig. 768.

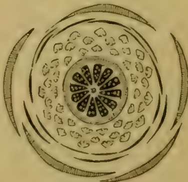


Fig. 769.

Fig. 767. Diagram of the flower of the Barberry (*Berberis*).——*Fig.* 768. Diagram of the flower of *Nymphæa*.——*Fig.* 769. Diagram of the flower of the Poppy.

ber. In many of the Ranunculaceæ (*fig.* 770), the stamens and carpels are very numerous, owing to addition of whorls. As a rule, the increase in the number of whorls is most common among the stamens. When the increase is not excessive, the number of the organs so increased is a multiple of the normal number of parts in each whorl; thus in the Barberry, the normal number is three, and that of the sepals, petals, and stamens, six, so that in each whorl we have double the normal number. When the addition of parts extends to beyond three or four whorls, this correspondence in number is liable to much variation; and when the addition is very great, as in the stamens of Clematis

(*fig.* 770), and carpels of *Liriodendron* (*fig.* 589, *c*), it cannot be well determined, in which case the symmetry is disguised or destroyed; which is also the case if the whorls are crowded together.

b. *Chorisis* or *deduplication.* —This is generally looked upon by botanists as another means of multiplication of the parts of a flower. It consists in the division or splitting of an organ in the course of its development, by which two or more organs are produced in the place of one. Chorisis differs from augmentation in the fact, that it not only increases the number of parts, but also interferes with their regular alternation; for augmentation does not necessarily interfere with alternation, it only obscures it when the number of additional parts is excessive, or when the whorls are crowded together.

Chorisis may take place in two ways, either transversely, when the increased parts are placed one before the other, which is called *vertical, parallel,* or *transverse chorisis*; or collaterally, when the increased parts stand side by side, which is termed *collateral chorisis.* *Transverse chorisis* is supposed to be of fre-

Fig. 770.

Fig. 771.

Fig. 770. Diagram of the flower of Clematis (*Ranunculaceæ*).——*Fig.* 771. Diagram of the flower of *Rhamnus catharticus*, Buckthorn.

quent occurrence; thus the petals of the Lychnis (*fig.* 486), and many other Caryophyllaceous Plants, exhibit a little scale on their inner surface, at the point where the limb of the petal is united to the claw. A somewhat similar scale, although less developed, occurs at the base of the petals of some species of Ranunculus (*fig.* 483). The formation of these scales is supposed by many, to be due to the chorisis or unlining of an inner portion of the petal from the outer. Other botanists consider these appendages as deformed glands. Each petal of Parnassia (*fig.* 485) has at its base a petal-like appendage divided into a number of parts, somewhat resembling sterile stamens; this is also stated to be produced by transverse chorisis.

In the natural orders Rhamnaceæ (*fig.* 771), Byttneriaceæ, &c., the stamens are opposite to the petals, hence they are supposed by many botanists to be produced by chorisis from the corolla; others, however, explain this opposition of parts by supposing the suppression of an intermediate whorl (see p. 364).

Transverse chorisis is also frequently to be found in the staminal whorl, but it is less frequent in the gynœcium. Examples of chorisis in the carpels are furnished, however, by *Sedum* (*fig.* 566), and *Crassula* (*fig.* 763), where each carpel has at the base on its outside a little greenish scale, which is supposed by some to be due to it.

It will be observed, that in all the above cases of transverse chorisis, the parts which are produced do not resemble those from which they arose, and this appears to be an universal law in this form of chorisis. We now pass to

Collateral chorisis. — We have a good example of this form in the Stock, Wallflower, and other plants of the natural order Cruciferæ. In these flowers, the two floral envelopes are each composed of four organs alternating with each other (*fig.* 772). Within these we find six stamens instead of four, as should be the case in a symmetrical flower; of which two are placed opposite to the lateral sepals and alternate with the adjacent petals, while the other four are placed in pairs opposite the anterior and posterior sepals; we have here, therefore, four stamens instead of two, which results from the collateral chorisis of those two. In some Cruciferæ, as *Streptanthus* (*fig.* 773), we have a strong confirmation of this view presented to us in the fact that, in place

Fig. 772.

Fig. 773.

Fig. 774.

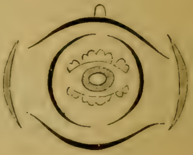


Fig. 772. Diagram of the flower of the common Wallflower.——*Fig.* 773. Flower of a species of *Streptanthus*, with the floral envelopes removed, showing a forked stamen in place of the two anterior stamens. From Gray.——*Fig.* 774. Diagram of the flower of Fumitory.

of the two stamens, as thus commonly observed, we have a single filament forked at the top, and each division bearing an anther, which would seem to arise from the process of chorisis being arrested in its progress. The flowers of the Fumitory are also generally considered to afford another example of collateral chorisis. In the flowers of this plant we have two sepals (*fig.* 774), four petals in two rows, and six stamens, two of which

are perfect, and four more or less imperfect; the latter are said to arise from collateral chorisis, one stamen here being divided into three parts. Other examples of this form are by some considered to be afforded by the flowers of many Hypericums (*fig.* 542), in these, each bundle of stamens is supposed to arise from the repeated chorisis of a single stamen. Collateral chorisis may be considered as analogous to a compound leaf which is composed of two or more distinct and similar parts. Transverse chorisis is supposed by Gray, and some other botanists, to have its analogue in the ligule of Grasses (*fig.* 351), as that appendage occupies the same position as regards the leaf, as the scales of the Lychnis, &c., do to the petals.

Dr. Lindley believes that the whole theory of chorisis "is destitute of real foundation for the following reasons: —

"1. There is no instance of unlining which may not be as well explained by the theory of alternation.

"2. It is highly improbable and inconsistent with the simplicity of vegetable structure, that in the same flower the multiplication of organs should arise from two wholly different causes; viz., alternation at one time, and unlining at another.

"3. As it is known that in some flowers, where the law of alternation usually obtains, the organs are occasionally placed opposite each other, it is necessary for the supporters of the unlining theory to assume that in such a flower a part of the organs must be alternate and a part unlined, or at one time be all alternate, and at another time be all unlined, which is entirely opposed to probability and sound philosophy.

"4. The examination of the gradual development of flowers, the only irrefragable proof of the real nature of final structure, does not in any degree show that the supposed process of unlining has a real existence." (Lindley's "Introduction to Botany," vol. i. p. 333.)

According to Lindley's view, therefore, whenever the organs of adjacent whorls are opposite to each other instead of alternate, this is supposed to arise from the suppression of a whorl which should be normally situated between the two that are present.

It would not be perhaps difficult to show, that the above reasoning of Dr. Lindley's is incorrect, but the present work is not adapted for the discussion of such a subject, as it would require more space than we could afford for its suitable investigation. To those who would wish to make themselves further acquainted with this matter, I would refer them to Gray's "Botanical Text Book," where the theory of chorisis, as well as the theoretical structure of the flower generally, is most ably treated of.

3. Suppression or Abortion. — The suppression or abortion of parts, may either refer to entire whorls, or to one or more

organs of a whorl. We shall treat this subject briefly under these two heads.

a. *Suppression or abortion of one or more whorls.*—We have already stated, that a complete flower is one which contains calyx, corolla, stamens, and pistil. When a whorl is suppressed therefore, the flower necessarily becomes incomplete. This suppression may either take place in the *floral envelopes*, or in the *essential organs.*

Sometimes one whorl of the floral envelopes is suppressed, as in *Chenopodium* (*fig.* 425), in which case the flower is *apetalous* or *monochlamydeous;* sometimes both whorls are suppressed, as in *Euphorbia* (*fig.* 497) and common Ash (*fig.* 426), when the flower is termed *naked* or *achlamydeous.*

When a whorl of the essential organs is suppressed, the flower is *imperfect*, as it then cannot by itself form seed. The stamens or the pistil may be thus suppressed, in both of which cases the flower is *unisexual.* When both stamens and pistil are suppressed, as in certain florets of some of the Compositæ, &c., the flower is *neuter.* When the stamens are abortive, the flower is termed *pistillate;* or when the pistil is absent, *staminate.* The terms *monœcious, diœcious, and polygamous*, which have reference to this point, have been already sufficiently explained. Some botanists, as already noticed (p. 361), consider that when the organs of adjacent whorls are opposite to each other instead of alternate, that such an arrangement of parts arises from the suppression of an intermediate whorl; but this view is manifestly insufficient to account for such a circumstance in all cases. Thus in the Rhamnaceæ (*fig.* 771), the stamens are opposite to the petals, and frequently united to them at the base, and we cannot but regard them as produced by transverse chorisis from the petals. In some cases, therefore, we regard the opposition of the parts of contiguous whorls to be due to suppression, and in others to chorisis.

b. *Suppression of one or more organs of a whorl.*—This is a very common cause of deviation from normal structure; we can here only bring forward a few examples.

This suppression of parts is most frequent in the gynœcium. Thus in the Cruciferæ (*fig.* 772), we have four sepals, four petals, six stamens, and two carpels; here two carpels are suppressed: in the Heart's-ease (*fig.* 775), we have a pentamerous flower, so far as the calyx, corolla, and stamens are concerned, but only three carpels, two carpels being suppressed: in many Leguminous Plants (*fig.* 776), we have five sepals, five petals, ten stamens, and only one carpel, four of the latter being here abortive: in plants of the order Compositæ (*figs.* 952 and 954), the calyx, corolla, and andrœcium, have each five organs, but only one, or, according to other botanists, two carpels.

In some species of *Impatiens* (*fig.* 777), we have five carpels,

five stamens, and five petals, but only three sepals; here two sepals are suppressed: in *Tropæolum pentaphyllum* (*fig.* 778),

Fig. 775.

Fig. 776.

Fig. 777.

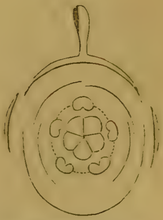


Fig. 775. Diagram of the flower of the Heart's-ease.——*Fig.* 776. Diagram of a Leguminous flower.——*Fig.* 777. Diagram of the flower of *Impatiens parviflora*.

there are five sepals, and but two petals; three of the latter being suppressed. In the Labiatæ and Scrophulariaceæ one of the stamens is commonly suppressed, and sometimes three;

Fig. 778.

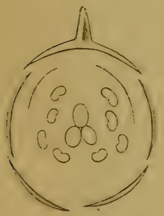


Fig. 779.

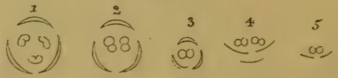


Fig. 778. Diagram of the flower of *Tropæolum pentaphyllum*.——*Fig.* 779. Diagram of flowers of Euphorbiaceous Plants becoming more and more simple. After Jussieu.

1. Staminate flower of *Tragia cannabina*.
2. " " *Tragia volubilis*.
3. " " *Anthostema senegalensa*.
4. " " *Andenopeltis colliguaya*.
5. " " *Euphorbia*.

thus in the *Lamium* (*fig.* 992) we have five parts to the calyx and corolla, but only four stamens; and in the *Salvia* (*fig.* 995) we have also five parts to the calyx and corolla, but only two perfect stamens.

The suppression of whorls and parts of a whorl are well illustrated by plants of the Euphorbiaceæ, and the above diagram from Jussieu will show this fact in a remarkable manner (*fig.* 779). Thus, in No. 1 we have a flower consisting of but two whorls, the petals and carpels being suppressed; in No. 2, while the same whorls are present, one of the stamens is absent; in No. 3 two stamens are suppressed; in No. 4 the calyx is suppressed, and one stamen, the place of the calyx being occupied by three bracts; while in No. 5 the place of the

calyx is occupied by two bracts, and there is only one stamen present, this of itself constitutes the flower, which is thus reduced to its simplest condition.

Besides the above examples of the suppression of parts, there is another kind of suppression, to which the term abortion more properly applies. This consists in the *degeneration* or *transformation* of the parts of a flower. Thus in *Scrophularia* the fifth stamen is reduced to a scale; in the Umbelliferæ the limb of the calyx is commonly abortive, while in the Compositæ (*figs.* 953 and 955) it is reduced to a pappose form. Many of the so-called nectaries of flowers are merely transformed stamens. In unisexual flowers, such as *Tamus*, the stamens are frequently present as little scales. In cultivated *semi-double* flowers, such transformations are very common; thus we frequently find the stamens and carpels partially transformed into petals; or when the flowers are entirely double, all the parts of the andrœcium and gynœcium are thus converted into petals.

4. Irregularity. — This irregularity may be produced by three different causes,— namely, unequal growth of the members of a whorl; unequal degree of union; and abnormal development of the thalamus or axis of the flower. The two first causes cannot well be separated, and will be treated of under one head.

a. *Unequal growth, and unequal degree of union of the members of a whorl* render such whorls irregular, and produce what are called irregular flowers. These irregular forms have been already treated of in describing the different floral organs. All the examples of irregular forms of calyx and corolla therefore, which have been alluded to under their respective heads, will afford good illustrations. The stamens of Papilionaceæ will afford an example of unequal union in the staminal whorl.

b. *Abnormal development of the thalamus or axis of the flower.*— The irregular forms of flowers due to this cause have been also alluded to when describing the thalamus. Thus the flowers of the Nelumbium (*fig.* 640), Ranunculus (*fig.* 530), Rose (*fig.* 439), Dianthus (*fig.* 587), Geranium (*fig.* 626), &c., will furnish examples of this form of irregularity.

CHAPTER 5.

REPRODUCTIVE ORGANS OF CRYPTOGAMOUS, FLOWERLESS, OR ACOTYLEDONOUS PLANTS.

The nutritive organs of Cryptogamous Plants have been already very briefly alluded to in the chapter on the General Morphology of the Plant, and in our description of the stem, root, leaf, &c. It only remains for us to describe their reproductive organs, which we shall do as briefly as is possible, our space not allowing us to take more than a general view of the subject.

The reproductive organs of Cryptogamous Plants differ widely from those of the Phanerogamia ; for, in the first place, they have no flowers properly so called,—that is to say, they have no stamens or carpels, the presence of which is essential to our notion of a flower ; hence they are termed *Flowerless Plants.* Although these plants have no true stamens or carpels, still recent investigations have proved, that they have other organs which perform analogous purposes, and to which the names of Antheridia, and Pistillidia or Archegonia, have been applied. These organs being more or less concealed or obscure, flowerless plants have been also called Cryptogamous, which signifies literally, concealed sexes. The term *asexual,* which was formerly applied, has now been generally proved to be incorrect.

Secondly, as Cryptogamous Plants have no flowers, they do not produce true seeds or bodies containing a rudimentary plant or embryo ; instead of seeds, they form reproductive bodies called *spores*, which in most cases consist of one cell (rarely more), composed of two or more membranes, enclosing a granular matter. A spore having no embryo can have no cotyledon, which is an essential part of the embryo, consequently flowerless plants have been also called *Acotyledonous.* In germination also, as they have no rudimentary stem or root, they have commonly no definite growth, but this takes place by an indifferent extension of one or both of their membranes. Some exceptions are, however, afforded to this latter peculiarity by the spores of certain Fungi, which have on their outer membrane certain spots or pores, through which, in germination, little threads are protruded from an extension of their inner membrane. This is exactly analogous to the production of the tubes from the pollen grains ; indeed, in their general structure, spores (especially those of the Fungi, which exhibit the above growth), have

a striking similarity to pollen. It must be noticed, however, that spores, although similar in structure to pollen, perform essentially different functions. The threads which are thus produced by the germination of spores, may either reproduce the plant directly; or give rise to an intermediate body of varying form, called the *pro-thallus* or *pro-embryo* (*fig.* 784, *p*), from which the fructiferous or fruit-bearing frond or stem ultimately springs.

Although Cryptogamous Plants have been thus described above as destitute of an embryo, yet it must be admitted that the spores of some of these plants do contain an analogous body,—that is to say, they contain a body which has all the elements of the future plant in a rudimentary state. Such spores are, however, of but rare occurrence, and the rudimentary plant which they contain is of so different a nature from the true embryo of Phanerogamous Plants, that such exceptional cases can scarcely be said to interfere materially with the character given above.

Such are the chief distinctive characters in the reproductive organs of *Cryptogamous* and *Phanerogamous* Plants. The nature of these organs in the different tribes of flowerless plants, are however, so remarkable, that, in order to make ourselves acquainted with them, it will be necessary for us to describe the peculiarities of each separately.

The Cryptogamous Plants have been divided by botanists into two great divisions, called respectively *Acrogens* and *Thallogens*, the characters of which will be described hereafter, when treating of Systematic Botany ; but it will be better for us to keep these two groups in view in our sketch of the reproductive organs of flowerless plants, and hence we shall treat of them under those two heads.

Section 1.—Reproductive Organs of Acrogens.

Acrogenous Plants have been also divided into several subdivisions, called *Natural Orders* or *Families;* these are the *Filices*, *Equisetaceæ*, *Marsileaceæ*, *Lycopodiaceæ*, *Musci*, *Hepaticaceæ*, and *Characeæ*. The general characters of these orders will be described under their respective heads in Systematic Botany ; — the nature of their reproductive organs have now only to be described.

1. Filices or Ferns. — The fructification of these plants consists of little somewhat rounded cases, called *capsules*, *sporangia*, or *thecæ* (*fig.* 780, *sp*), springing commonly from the veins on the under surface or back of the leaves or fronds (*figs.* 780 and 781), and containing spores in their interior. In a very few cases sporangia have been observed on the upper surface, as in *Acrostichum*. The sporangia are arranged in little heaps, which vary much in form, called *sori* (*figs.* 780 and 781, *s*), and are either naked, as in *Polypodium* (*fig.* 780), or

covered by a thin membranous layer continuous with the epidermis, which is called the *indusium* or *involucre*, as in *Nephrodium* or *Lastræa Filix-mas* (*fig.* 781). Sometimes the sporangia are so densely compacted that, no intervening parenchyma can be distinguished — the latter being destroyed by the excessive development of the former ; in such cases, the sporangia instead of being collected in sori on the back of the fronds, appear as little bodies arranged in a spiked manner on a simple or branched rachis, as in *Osmunda* (*fig.* 782).

Fig. 780.

Fig 781.

Fig. 782.

Fig. 780. A portion of the frond of the common Polypody (*Polypodium vulgare*) showing two sori springing from its veins. The sori are naked, and consist of a number of sporangia, *sp*, in which the spores are contained.——*Fig.* 781. Portion of the frond of the male-fern (*Nephrodium Filix-mas*), with two sori, *s*, *s*, covered by an indusium or involucre.——*Fig.* 782. Portion of the frond of the Royal or Flowering-fern (*Osmunda regalis*), with its sporangia arranged in a spiked manner on a branched rachis.

The sporangium is a little cellular bag or case (*fig.* 783, *s*), usually stalked, *p*, and more or less completely surrounded by a ring or *annulus* ; this ring is frequently elastic, and thus causes the bursting of the sporangium when ripe, and the escape of its spores. In some Ferns the ring is imperfect, and in others it is altogether wanting ; hence Ferns provided with a ring are called *annulate*, whilst those in which it is absent are *exannulate*.

The spores have two coats like pollen-grains ; and like them also, the outer coat is either smooth, or furnished with little points, streaks, or reticulations, &c. In germination (*fig.* 784, *s*) the outer coat bursts, and the inner is protruded in the form of an elongated tube, which ultimately by cell-division, forms a thin, flat, green parenchymatous expansion, called a *prothallus* or *pro-embryo*, *p*, from which one or more radical fibres, *r*, are commonly produced in its earliest stage. On the under surface of this body, there are soon produced two different

structures, called *antheridia* and *archegonia*, which are now considered as the organs of reproduction. The *antheridia* are

Fig. 783.

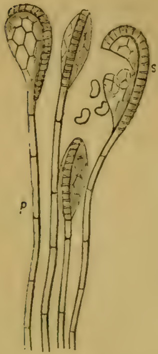


Fig. 784.

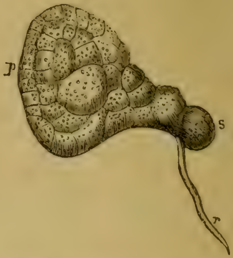


Fig. 783. Sporangia of a Fern (*Marginaria verrucosa*). *s*. Sporangium, supported on a stalk, *p*, and surrounded by a ring or annulus, which is a continuation of the stalk. One sporangium is represented as burst on one side, and the spores in the act of being scattered.——*Fig.* 784. Germinating spore of a species of Fern. *s*. Spore. *p*. Pro-thallus. *r*. Radical fibre.

stalked cellular bodies (*fig.* 785), containing other minute cells called sperm-cells, *se*, in which are developed spiral ciliated filaments, *sp*, termed *spermatozoids* or *phytozoa*. The *archegonia* or *ovule-like* bodies (*fig.* 786) are little cellular papillæ of a somewhat oval form, with a canal in the centre leading to a cell called the *germ-cell* or *embryo-cell*, and which is contained in

Fig. 785.

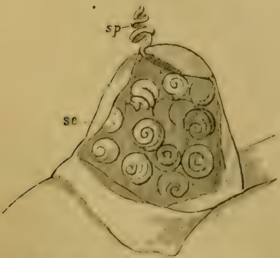


Fig. 786.

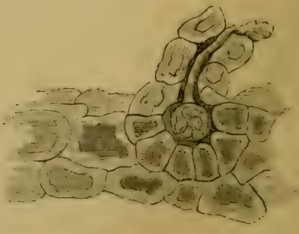


Fig. 785. Side view of an *antheridium* containing a number of *sperm-cells*, *se*. *sp*. *Spermatozoids* escaping from the antheridium after having burst the sperm-cells. After Henfrey.——*Fig.* 786. Vertical section of an archegonium, passing through the canal and embryo-sac. After Henfrey.

a cavity called the *embryo-sac.* After impregnation has taken place, the embryo-cell develops and forms an embryo, from which ultimately, the plant with fronds bearing sporangia is produced. The Ferns are thus seen to exhibit in their growth two stages; in the first of which, the spore produces a thalloid expansion resembling the permanent state of the *Hepaticaceæ* (*figs.* 808 and 810); and in the second, peculiar bodies are formed upon the surface of the pro-thallus, by the action of which there is ultimately produced a new plant resembling the one from which the spore was originally derived. Thus, Ferns exhibit an instance of what is called *alternation of generations.*

2. Equisetaceæ or Horse-tails.—In these plants the fully developed fructification is borne in cone-like or club-shaped masses at the termination of the stem (*fig.* 157). Each mass is composed of a number of peltate stalked scales, on the under surface of which numerous sporangia are arranged (*fig.* 787). These sporangia when ripe, open by a longitudinal fissure on their inner surface. Some botanists consider each of these scales bearing sporangia on its under surface as a single organ; and the sporangium is then described, as a stalked "mushroom-shaped body, possessing a number of little pouch-like cases under the overhanging outer portion, and round the stalk; these pouches bursting by a perpendicular slit inwards so as to discharge the spores."

The spores present a very curious structure; they are little rounded or somewhat oval bodies, and are regarded by Henfrey as only possessing one true coat, in consequence of the outer coat splitting up in a spiral direction so as to form two elastic appendages which are attached by their middle to the spores, and are terminated at each end by a club-shaped ex-

Fig. 787.

Fig. 788.

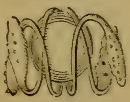


Fig. 789.

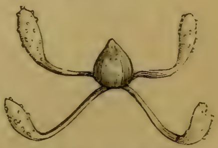


Fig. 787. Peltate stalked scale of a species of Horse-tail (*Equisetum*), bearing on its lower surface a number of sporangia.——*Fig.* 788. Spore of a Horse-tail furnished with two *elaters*, which are wound round it. The elaters are terminated at each end by a club-shaped expansion.——*Fig.* 789. The same spore in a dry state, showing the elaters in an uncoiled condition.

pansion (*figs.* 788 and 789). These spiral elastic filaments, which are called *elaters*, are at first wound round the spore (*fig.* 788), but when dry they ultimately uncoil (*fig.* 789), and thus appear to assist in the dehiscence of the sporangium, and in the dispersion of the spore to which they are attached.

When these spores germinate, a little pouch-like process protrudes from their surface by an elongation of their membrane; this ultimately forms a green, lobed, flattened expansion, resembling in all its essential characters the *pro-thallus* of a Fern. Like Ferns also, this pro-thallus becomes furnished with *antheridia* containing ciliated *spermatozoids*, and *archegonia*. From the embryo or germ-cell of the archegonium also, as in Ferns, a new plant is ultimately produced resembling in every respect that of the parent plant from which the spores were obtained. As is the case in Ferns therefore, we have in the Equisetaceæ also, an instance of *alternation of generations*.

3. Marsileaceæ or Pepperworts.—In the plants of this order the fructification is placed at the base of the leaf-stalks. It consists usually of a two-valved stalked *involucre* or *sporocarp* (*fig.* 790), which is generally many-celled, or sometimes one-celled, and appears to be a modified leaf. The contents of the sporocarps, and the mode in which they are arranged, differ somewhat in the different genera of this order, and hence it will be necessary for us to allude to them separately.

In *Marsilea*, the fructification consists of a stalked, two-valved, hardened sporocarp (*fig.* 790, *s*). The valves are held together by a mucilaginous ring, which is at first connected with the stalk of the sporocarp, but when the latter organ bursts, the ring becomes detached from the stalk at one end, straightens, and appears as a long mucilaginous cord protruding from the sporocarp (*fig.* 790, *p*), and bearing on its sides somewhat oblong spikes of fructification (*fig.* 790, *f*). These spikes are at first enveloped in a membrane, and are composed of two distinct organs, called *antheridia*, and *pistillidia sporangia* or *ovules*; these are attached to a sort of placenta, the antheridia being on one side, and the sporangia on the other.

Each sporangium contains but one spore. It consists of a central nucleus, surrounded by a cellular coating except at its apex, where there is a little cavity (*fig.* 792). According to Hofmeister, as quoted by Berkley, "this cavity is gradually filled up with cellular tissue, constituting a conical pro-thallus confluent with the nucleus. A single archegonium is formed in the centre, the orifice of which corresponds with the apex of the pro-thallus." In this an embryo is ultimately formed, which, when it germinates, gives off a frond in one direction and a root opposite to it.

The antheridia contain a number of small cells (*fig.* 791), which ultimately develop long spiral spermatozoids. These small cells are sometimes called *pollen-spores* or *small spores*, while the large germinating spore is called the *ovulary-spore* or *large spore*.

In *Pilularia*, the fructification consists of stalked, pill-shaped, hairy sporocarps, situated at the base of the leaves. The in-

terior of each sporocarp is divided usually into four cells (*fig.* 793), and when ripe it opens by four valves. In the interior

Fig. 790.

Fig. 791.

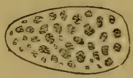


Fig. 792.

Fig. 790. Fructification of a species of *Marsilea*. *s*. Two-valved sporocarp. *p*. Peduncle. *f*. Fructification.——*Fig.* 791. Antheridium of the above.——*Fig.* 792. Ovule or sporangium of the above. After Maout.

of each cell there is a mucilaginous process or placenta attached to the walls, upon which are placed numerous antheridia and sporangia or ovules, as in *Marsilea*. The structure of these antheridia and sporangia resembles in all essential particulars those of *Marsilea*. In fact, the only difference between the fructification of *Marsilea* and *Pilularia*, is the more complicated nature of the sporocarps in *Marsilea*.

The fructification of *Salvinia* (*fig.* 794) and *Azolla*, appears to resemble that of *Marsilea* and *Pilularia*, except that the antheridia, *a*, and sporangia or ovules, *b*, are here contained in separate sacs, and are attached to a sort of central cellular placenta (*fig.* 794). In germination also, the pro-thallus of

Fig. 793.

Fig. 794.

Fig. 793. Transverse section of the sporocarp or spore-fruit of *Pilularia globulifera*. After Henfrey.——*Fig.* 794. Vertical section of the sporocarp of *Salvinia*, showing sporangia in one cavity, *b*, and antheridia in the other, *a*.

Salvinia differs from *Marsilea* and *Pilularia*, in producing several archegonia, instead of only one, as is the case with them. *Azolla* requires further investigation.

In reviewing the fructification of the Marsileaceæ, we find that, it differs from the Filices and Equisetaceæ, in producing two distinct kinds of spores, and in the pro-thallus not forming a distinct expansion on the outside of the spore as is the case with them, but being confluent with the spore. These characters show that, the Marsileaceæ are nearly allied to the Lycopodiaceæ, which we now proceed to describe.

4. Lycopodiaceæ or Club-mosses. — The fructification in this family is situated on the upper surface of the leaves at their bases (*figs.* 795 and 796). The leaves thus bearing the fructification are frequently collected together into a kind of cone or spike (*fig.* 156), while at other times, they are scattered along the stem. The spores, like those of Marsileaceæ, are of two kinds, and are enclosed in separate cases. These cases are variously named ; the names which would correspond to those just used in describing the Marsileaceæ would be *sporangia* and *antheridia* ; but the former are also commonly called *oosporangia* or *oophoridia* (*fig.* 795), and the latter *pollen-sporangia* (*fig.* 796). The contents of the former are generally termed *large spores* or *macrospores* (*fig.* 798), those of the latter *small spores*

Fig. 795.

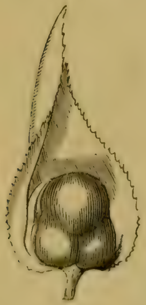


Fig. 796.

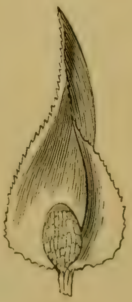


Fig. 797.

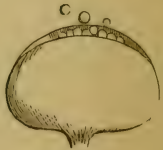


Fig. 798.

Fig. 795. Scale or leaf of "*Selaginella apoda*" with *oosporangium* or *oophoridium* in its axil. After Henfrey.——*Fig.* 796. *Pollen-sporangium* or *antheridium* of the above. After Henfrey.——*Fig.* 797. Pollen-sporangium of a species of *Selaginella*. It is two-valved, and contains a number of small spores or *microspores*. ——*Fig.* 798. Oosporangium of a species of *Selaginella*. This is a two-valved, four-lobed sac, and contains four large spores or ovules, called *macrospores*.

or *microspores* (*fig.* 797). It is greatly to be regretted that a uniform nomenclature should not be adopted with the repro-

ductive organs of the Cryptogamous Plants by using the same terms in the different families for homologous organs.

The *oosporangia* or *oophoridia* are usually two-valved cases (*fig* 795 and 798) with four lobes, each of which contains one large spore. The oophoridium is commonly only one-celled, but in some genera it is two, three, or many-celled.

The *antheridia* or *pollen-sporangia* are somewhat reniform, two-valved cases (*fig.* 796 and 797), containing a large number of small spores (*microspores*), in which spermatozoids are ultimately produced.

In *Lycopodium* and some other Lycopodiaceæ, only one kind of spore case has been found, which is of the nature of the antheridium or pollen-sporangium.

The large spores are considered by Hofmeister and others, as the analogues of the ovules. The antheridia are therefore to be considered as the male organs, and the oophoridia as the female.

In germination, the large spore produces a pro-thallus in its interior, thus resembling the Marsileaceæ ; in this archegonia are soon developed, in which an embryo, and ultimately a new plant is produced.

5. Musci or Mosses. — The reproductive organs of this vast order of Cryptogamous Plants are of two kinds ; these are called *antheridia* (*fig.* 799), and *archegonia* or *pistillidia* (*fig.* 800)

Fig. 799.

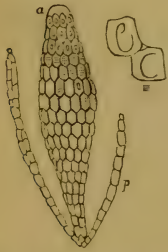
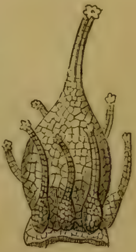


Fig. 799. Antheridium, *a*, of the Hair-Moss (*Polytrichum*), containing a number of cells, *c*, in each of which there is a single *phytozoon* or *spermatozoid*. *p*. *Paraphyses*, surrounding the antheridium. —— *Fig.* 800. Archegonium or pistillidium of a moss.

Fig. 800.



They are surrounded by leaves, usually of a different form and arrangement to those of the stem, which are called *perichætial* (*fig.* 802, *f*), and in some Mosses they have, in addition to the perichætial leaves, another covering formed of three or six small leaves, of a very different appearance to them, termed *perigonial*, and constituting collectively a *perigone*. The antheridia are regarded as the male organs, and the archegonia as the female.

The antheridia and archegonia sometimes occur in the same

perigone, in which case such Mosses have been termed *hermaphrodite.* More frequently however, they are in different perigones, and then both kinds of reproductive organs may occur on the same plant, or on separate plants; in the former case we apply the term *monœcious*, in the latter *diœcious* (*figs.* 154 and 155).

The *antheridium* is a somewhat elliptical, more or less rounded or elongated cellular sac (*fig.* 799), which is filled at maturity with a number of minute cells, *c*, which have been termed *zoothecæ;* in each of these there is a single spiral *phytozoon* or *spermatozoid.* The antheridium opens by an irregular perforation at its apex, and thus discharges the cells with their phytozoa. Among the antheridia there are generally to be found, slender, cellular, jointed threads (*fig.* 799, *p*), called *paraphyses*, which are probably nothing more than abortive antheridia, as they appear to perform no special function.

The archegonia, like the antheridia, are often surrounded by filamentous cellular bodies, called *paraphyses*, which appear to be in this case abortive archegonia (*fig.* 800). The archegonium is a flask-shaped cellular body with a long neck, the whole somewhat resembling an ovary with its style and stigma. The neck is perforated by a canal which leads into a cavity, at the bottom of which is a single cell, called the *germ* or *embryonal-cell.* The case of the archegonium is called the *epigone.* After fertilization this embryonal cell enlarges and is elevated on a stalk, and as it grows upwards it bursts the epigone, and carries one portion of it upwards as a kind of hood, while the other portion remains below as a sort of sheath round the stalk. The central portion formed by the development of the embryonal cell, is called the *sporangium* (*fig.* 801, *sp*), the stalk the *seta* (*figs.* 801, *t*, and 802, *p*), the hood the *calyptra* (*fig.* 802 and 803, *c*), and the sheath at the base, the *vaginule* (*fig.* 801, *v*).

The *sporangium* when fully formed, is a hollow urn-like case (*figs.* 803 and 804), the centre of which is usually occupied by a cellular axis, called the *columella* (*fig.* 807), and the space between this axis and the walls of the sporangium is filled with free spores, which are small cells with two coats and markings resembling those of pollen-grains. The sporangium is either indehiscent ; or it opens by four vertical slits so as to form four valves; or more commonly by a transverse slit close to the apex like transverse dehiscence in fruits, by which a kind of lid is formed, called the *operculum* (*figs.* 804, *o*, and 805), this lid is either persistent or deciduous. The sporangium is sometimes much dilated at the base, where it joins the seta ; this swelling is called an *apophysis*, or, if it only occurs on one side, a *struma.*

The wall of the sporangium is commonly described as consisting of three cellular layers, the outer of which forms the operculum, and the inner two layers the *peristomium.* At the

Fig. 801. *Fig.* 802. *Fig.* 803. *Fig.* 804. *Fig.* 805.

Fig. 801. *Coscinodon pulvinatus.* *sp.* Sporangium enclosed in the *calyptra.* *t. Seta* or stalk. *v.* Vaginule. From Henfrey.——*Fig.* 802. The Hygrometric Cord-Moss (*Funaria hygrometrica*). *f.* Perichætial leaves. *p.* Stalks or *setæ*, each of which supports a sporangium, *u*, covered by a calyptra, *c*. *o.* Operculum.——*Fig.* 803. Sporangium of the Extinguisher-Moss (*Encalypta vulgaris*) before dehiscence. *u.* Sporangium, covered by a transparent calyptra, *c*, and supported on a seta, *s*. Beneath the calyptra is seen the lid or operculum, *o*.——*Fig.* 804. The sporangium of 803 after dehiscence. The calyptra and operculum, *o*, being removed, the *peristome*, *p*, may be seen.——*Fig.* 805. *Pottia truncata*, showing the separation of the operculum from the sporangium. From Henfrey.

dehiscence of the sporangium the *stoma* or *mouth* is entire, smooth or unfurnished with any processes (*fig.* 805); or it is surrounded by one or two fringes of teeth, called the *peristome*, which are formed from the two inner layers of the wall of the sporangium (*fig.* 804, *p*). These teeth are always four or some multiple of that number. Sometimes a membrane from the inner wall is stretched across the mouth of the sporangium, and forms what has been called the *epiphragma* or *tympanum* (*fig.* 806, *e*). When the mouth is naked, the Mosses in which such a sporangium is found are called *gymnostomous* or *naked-mouthed;* when

Fig. 806. *Fig.* 807.

Fig. 806. Sporangium, *u*, of Hair-Moss deprived of its calyptra and operculum. *p.* Peristome. *e.* *Epiphragma* or *tympanum.*——*Fig.* 807. Transverse section of a sporangium of Hair-Moss, showing the columella surrounded by free spores.

the mouth is surrounded by a single row of teeth the Mosses are said to be *aploperistomous;* or, when with two rows, they are *diploperistomous.* The different appearances presented by the teeth, as well as their number and degree of cohesion, form important distinctive characters in the different genera of Mosses. The operculum as already stated, is formed by a projection of the outer layer of the wall of the sporangium. At the point where the operculum separates an elastic ring or *annulus* is produced, which encircles the mouth of the sporangium.

In germination, the inner coat of the spore is protruded as a tubular process, which, as it elongates by cell-division, forms a green, cellular, branched mass or *pro-thallus*, like a Conferva. As described by Berkley, "this mass is very much of the same nature as the mycelium of Fungi, and is called the *Protonoma*, and is always distinguished by the cells containing chlorophyll. Many spores may concur in the formation of this mass; but whether more spores than one concur in the formation of a single plant is doubtful. Be this as it may, after a time a little knot or swollen articulation appears upon the threads, which by cell-division, is developed into a leafy shoot, upon which archegonia and antheridia are afterwards developed."

The archegonium of Mosses is regarded by Henfrey, as quoted by Balfour, "to resemble the so-called ovules of Club-mosses and Pepperworts,—the archegonium giving rise to sporangiferous individuals. There is thus a compound organism, in which a new individual, forming a second generation, developed after a process of fertilization, remains attached organically to its parent, from which it totally differs in all anatomical and physiological characters. It is an instance of alternation of generations."

6. HEPATICACEÆ OR LIVERWORTS. — The reproductive organs of Liverworts are of two kinds like those of Mosses, to which this order is closely allied; they are called *antheridia*, and *archegonia* or *pistillidia*, and both kinds may be found on the same plant, or on different plants.

The *antheridia* or male organs are variously situated in the different genera of this order; thus in the leafy plants, they are placed in the axils of leaves, as in some Jungermanniæ; in others, they occur in the substance of the frond or thalloid expansion, as in *Riccia*, *Fimbriaria*, &c.; and in others, as in *Marchantia*, they are found imbedded in the upper surface of peltate or discoid-stalked receptacles (*fig.* 808, *r*). The antheridia are small, generally shortly stalked, cellular sacs, of an oval, globular, or somewhat flask-shaped form (*fig.* 809). Their walls are usually formed of a double layer of cells, surrounding a number of small cells in their interior. When ripe the antheridium bursts and discharges its contents; the internal small cells also burst, and each emits a single, very small, spirally wound *phytozoon* or *spermatozoid.*

The *archegonia* or *pistillidia*, like the antheridia, are differently arranged in different genera; thus in *Riccia* they are imbedded

Fig. 808.

Fig. 809.

Fig. 808. A portion of the thallus of *Marchantia polymorpha*, showing an antheridial receptacle, *r*, supported on a stalk, *s*.——*Fig.* 809. Antheridium of *Marchantia*, discharging its small cellular contents.

in the substance of the frond, while in *Jungermannia* and *Marchantia* (*fig.* 810) they are contained in receptacles, *r*, which are elevated above the thallus on stalks, *s*. They are usually small flask-shaped bodies, consisting of a cellular case or *epigone* (*fig.* 811), having a canal in its upper elongated portion which leads to a cavity, at the bottom of which a single

Fig. 810.

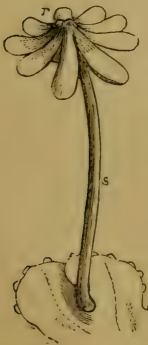
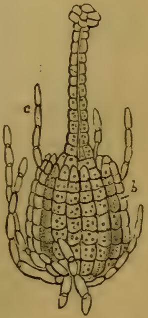


Fig. 810. A portion of the thallus of *Marchantia polymorpha*. *r*. Receptacle supported on a stalk, *s*. On the under surface of the receptacle the pistillidia are imbedded.——*Fig.* 811. Archegonium of *Marchantia*. *b*. *Perigone*, open at its apex, and surrounding an inner cellular case or *epigone*. *c*. *Paraphyses*.

Fig. 811.



free cell, called the *germ* or *embryonal* cell, is developed. After fertilization, this cell enlarges and bursts through the epigone, the latter either remaining only as a sort of sheath round its base called the *vaginule*, or the epigone opens by a transverse fissure, and the upper part is then carried upwards as a sort of hood or styloid *calyptra*. The *sporangium* thus formed by a development of the embryo cell, has also at times an additional covering surrounding the epigone, called the *perigone*, which frequently grows up so as to form a sort of cup-shaped covering (*fig.* 811, *b*). At the base of the perigone, a number of cellular filaments, perichætial leaves, or paraphyses, are also occasionally to be found (*fig.* 811, *c*).

The sporangia vary much in different genera. In *Marchantia* they are formed of two layers or sets of cells; one external, called the *cortical* or *peripheral* layer, and one internal, in which the spores, &c., are developed. The cells of the cortical layer exhibit spiral fibres, like the cells constituting the inner lining of the anthers in Flowering Plants. The cells forming the internal mass are thus described by Henfrey: — "At an early period the cells of the internal mass present the appearance of a large number of filaments radiating from the centre of the sporangium to the wall. These soon become free from each other, and it may then be perceived that some are of very slender diameter, and others three or four times as thick. The slender ones are developed at once into the long *elaters* (*fig.* 812, *e*) characteristic of this genus, containing a double spiral fibre, the two fibres, however, coalescing into one at the ends. The thicker filaments become subdivided by cross partitions (*fig.* 145, *a*, *b*), and break up into squarish free cells, which are the parent-cells of the spores, four of which are produced in each (*fig.* 145, *c*, *d*)." The sporangia in this genus are situated on the under side of the receptacle, and vary in form; — they burst by valves. In *Jungermannia* the sporangia are elevated upon stalks arising out of the vaginule; they are more or less oval in form, and open by four valves which spread in a cross-like form; they contain spore-cells and *elaters* with a single spiral filament. In *Anthoceros* the sporangia open by two valves, and have a central axis or *columella*; they are of an elongated, tubular, or conical form, situated on a short stalk, and contain spore-cells and elaters, but the latter have no

Fig. 812.

Fig. 812. Elaters, *e*, of *Marchantia*. *s*, *s*. *Sporidia*.

spiral fibres in their interior, and are much simpler in their structure than those previously described. In *Riccia* the sporangia are imbedded in the substance of the frond, and have neither elaters nor columella. They have no regular dehiscence.

The spores have usually two coats, like pollen-grains; the outer coat also frequently presents markings of different kinds: in *Marchantia* however, the spore has but one coat. They all germinate without any well-marked intermediate pro-thallus, although some produce a sort of confervoid mass or mycelium.

7. Characeæ or Charas. — There is still much difference of opinion among botanists as to the position of this order. The Charas have been commonly placed among the Algæ; but the structure of their reproductive organs indicates for them a higher position. They are generally considered as intermediate in their nature between Hepaticaceæ and Algæ, while by Berkley, whose opinions on all matters connected with Cryptogamous Plants are eminently worthy of consideration, they have been classed with the Acrogens; and, in accordance with his views, we have also placed them in that division of the Cryptogamous Plants.

The reproductive organs are of two kinds, both of which grow at the bases of the branches (*fig.* 813), and either on the same or on different branches of the same plant, or on different plants. These organs are called respectively, the *globule* (*fig.* 813, *g*), and the *nucule* (*fig.* 813, *n*).

The *globule*, which is regarded as an antheridium, is a globular body (*fig.* 813, *g*), of a deep brick-red colour, usually placed immediately below, or occasionally on the side of the nucule. It consists of eight valves, each of which is composed of a

Fig. 813.

Fig. 814.

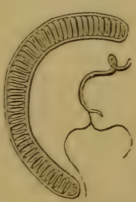


Fig. 815.

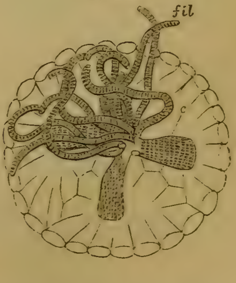


Fig. 813. A portion of the axis of *Chara*, with nucule, *n*, arising from the axil of a branch, and a globule, *g*, below it.——*Fig.* 814. A portion of a filament, *fil*, of *fig.* 815, with a ciliated *spermatozoid* or *antherozoid* by its side.——*Fig.* 815. A globule cut in half, to show the oblong cells, *c*, and the septate filaments, *fil*. After Henfrey.

number of cells radiating from a central cell. The valves are crenate or toothed at their margins, by which they become dovetailed as it were, with the adjoining valves. From the centre of each valve an oblong cell (*fig.* 815, *c*) is given off in a perpendicular direction. The eight cells from the eight valves converge in the centre of the globule, and are united at their extremities by a little cellular mass. A ninth cell of a similar form, but larger than the others, joins them in the centre; this is the stalk which fixes the globule to the branch upon which it is placed, and which enters its interior by penetrating between the four lower valves. From the point where the nine cells meet, numerous confervoid filaments are given off (*fig.* 815, *fil*), in each cell of which is produced a spiral *spermatozoid* or *antherozoid* (*fig.* 814), each of which is furnished with two very long ciliæ of excessive fineness. These ultimately escape from the cell by a sudden movement resembling the action of a spring, and may then be seen to exhibit active movements in water. M. Thuret (from whose description the above account of the globule is condensed), considers the spermatozoids of the Charas to be unquestionably of the same nature as those of Mosses.

The *nucule* or *spore* is by some considered as a pistillidium. It is an oval sessile body, situated in the axil of a branch (*figs.* 813, *n*); it consists of a central sac containing protoplasm, oil, and starch granules (*fig.* 817), surrounded by five cells, which are wound spirally round it, and terminating above in five or ten smaller cells, the ends of which remain free (*fig.* 816, *a*), and thus form a kind of crown at the apex of the nucule. At an early stage of growth the cells are separated from each other, and a canal is thus left between them extending from the crown towards the central cell. This canal is supposed to form a passage, by means of which the spermatozoids reach the central cell of the nucule. Ultimately the nucule drops off, and germinates in a manner closely resembling a Monocotyledonous Plant, by which a new plant is formed. No intermediate pro-thallus is produced.

Fig. 816.

Fig. 817.

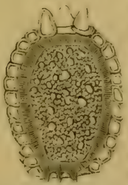


Fig. 816. Nucule of *Chara*. *a*. Apices of the spirally wound cells.——*Fig.* 817. Vertical section of the nucule of *Chara*.

Section 2.—Reproductive Organs of Thallogens.

The Thallogens may be divided into three large groups, called respectively, Lichenes, Fungi, and Algæ, each of which again comprises a number of subordinate divisions. The general characters of these will be described hereafter in Systematic

Botany. At present we have only to examine their reproductive organs, and of these even we can only afford space for a general sketch.

1. Lichenes or Lichens. — The reproductive organs of this large group of plants, are by no means so well understood as those of the Acrogenous Cryptogams already described. From the researches of M. Tulasne and others, it would appear that the reproductive organs of Lichens are of three kinds, namely, of 1. *Apothecia* of various forms, containing a number of spore-cases, called *asci* or *thecæ*, and which are supposed to represent the female organs; 2. *Spermogonia*, *spermagonia*, or *spermatogonia*, which have been regarded by some as antheridia or male organs; and 3. *Pycnidia*, containing *stylospores*.

The *apothecia* are of various forms, and have received different names accordingly. The more usual forms are round (*fig.* 819, *ap*) and linear; in the latter case they are commonly termed *lirellæ* (*fig.* 818). They may be either sessile or stalked; in the latter case the stalk has received the name of *podetium*. The apothecium is either composed of two parts, called the *thalamium* and *excipulum*, or, of the former only. The latter when present forms a partial or entire covering to the thalamium. The body of the apothecium constitutes the *thalamium*, and the layer of cells at the bottom of this upon which the thecæ and paraphyses are placed is termed the *hypothecium*. When the apothecium is divided by a vertical section, it is seen to contain a number of *asci* or *thecæ*, surrounded by thread-like or somewhat club-shaped filaments, called *paraphyses* (*fig.* 820), which are usually regarded as abortive asci; the asci and the paraphyses are placed perpendicularly upon the hypothecium. The apothecia are frequently of a different colour to the surrounding thallus; this is due to the paraphyses or excipulum. Each theca generally contains eight spores, but in some cases only four, in others sixteen; thus the spores are generally a multiple of two, and

Fig. 818.

Fig. 819.

Figs. 820. 821.

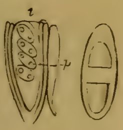


Fig. 818. Thallus of *Opegrapha atra* showing lirellæ.——*Fig.* 819. Portion of the thallus of *Parmelia parietina*, with young *apothecia*, *ap*, and *spermagonia*, *sp*. After Henfrey.——*Fig.* 820. A *theca*, *t*, of a Lichen, surrounded by paraphyses. The theca contains four spores or sporidia, *p*.——*Fig.* 821. One of the spores of the above divided into two cells.

the number is always constant for each species. In rare cases the thecæ have a large number of spores, and are hence said to be polysporous. The spores are sometimes termed *sporidia* or *sporules*. Some of these spores are of a very complex structure, being divided into two (*fig.* 821), four, or many cells. They are frequently beautifully coloured, and form splendid objects under the microscope.

In two genera of Lichens, namely, in *Abrothallus* and *Scutula*, certain structures have been discovered by Tulasne, called *stylospores*. These are analogous to the stylospores of Coniomycetous Fungi. "They consist of isolated spores borne upon shortish simple stalks. They are produced in conceptacles to which is applied the name of *pycnidia*."

The *spermagonia* or *spermatogonia* were first discovered by Tulasne, but they have been now found in a great number of Lichens, and probably exist in all. They generally appear as little black specks near the margins of the thallus, in the tissue of which they are usually more or less imbedded (*fig.* 819, *sp*); rarely, they are quite free and above the thallus. The spermagonium varies in form, and has one or more cavities, with a small orifice at the top termed the *ostiole* or *pore* (*fig.* 822, *os*), with which all the cavities communicate. The spermagonium

Fig. 822.

Fig. 823.

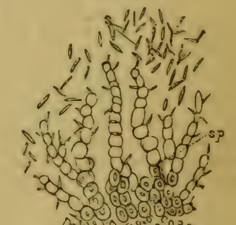


Fig. 822. Vertical section of a spermagonium of *Cladonia rangiferina*. *sp*. Spermatophores. *os*. Ostiole or pore, from which the spermatia, *s*, are escaping. After Henfrey.——*Fig.* 823. Highly magnified fragment from the wall of a spermagonium of *Parmelia parietina*. *sp*. Articulated spermatophores. *s*. Spermatia. After Henfrey.

when mature, has its interior filled with a number of bodies called *spermatia* (*figs.* 822, *s*, and 823, *s*), raised on stalks, termed *spermatophores* (*figs.* 822, *sp*, and 823, *sp*). The form of the sperma-

tophores varies much; according to Henfrey, "The simplest are short slender stalks, simple or branched; or they are articulated branches composed of a great number of cylindroid or globular cells (*fig.* 823, *sp*); or the branches are reduced to two or three elongated cells. The *spermatia* are terminal on the spermatophores, and consist of exceedingly minute bodies, ordinarily linear, very thin, short or longish, straight or curved, without appendages, and motionless, and lie in a mucilage of extreme transparency. These spermatia are commonly regarded as the analogues of the spermatozoids produced in the antheridia of the higher Cryptogams." When the spermagonium is mature, the spermatia are discharged through the pore or ostiole in vast numbers (*fig.* 822).

Besides the above reproductive organs of Lichens, there are also to be found in some genera, certain round cells filled with a green substance, called *gonidia*, which are also capable of reproducing the plant. They appear to be analogous organs to the buds of the Phanerogamia.

2. Fungi or Mushrooms.—This order is remarkable for the great development of its reproductive apparatus, which in most cases constitutes the principal portion of the plant. This reproductive structure varies very much in the different tribes of this vast group of plants, and can only be very briefly alluded to here. The vegetative structure of the Fungi consists of colourless, delicate, jointed, anastomosing filaments, called the *mycelium* or *spawn* (*figs.* 150—152), which corresponds to the thallus of the other Thallogens.

From the recent researches of M. Tulasne, it would appear, that the reproductive organs of Fungi are at least of three kinds, namely, 1. *Spores*, either naked (*fig.* 825); or enclosed in cases, called *thecæ, asci, cystidia*, or *sporangia* (*fig.* 826), and which are supposed to represent the female apparatus; 2. *Spermatia* (*fig.* 827), which are either developed among the spore-producing bodies, or on different parts of the plant. They are sometimes found in distinct receptacles like those of Lichens, which are accordingly termed *spermagonia*. These spermatia have been supposed by some to be the analogues of the spermatozoids found in the antheridia of the higher groups of Cryptogamous Plants, and hence to represent the male apparatus, but their functions are as yet by no means clearly ascertained; and 3. *Stylospores* enclosed in *pycnidia*. (See p. 384.)

The *spores*, as we have just mentioned, may be either naked, or enclosed in cases. We will investigate these two structures separately. The simplest form of the former is seen in such Fungi, as *Torula*, *Penicillium* (*fig.* 151), and *Botrytis* (*fig.* 152); where one or more cells placed at the ends of simple or branched filaments springing from the mycelium, are transformed into spores. The term *conidia* has been used to distin

guish certain forms of stalked spores which thus arise mycelium: these *conidia* may be regarded as a fourth kind of reproductive organ. Their nature is at present but imperfectly ascertained, they appear physiologically to be analogous to the *gonidia* of lichens.

In other Fungi which have naked spores, or *exospores* as they are sometimes termed, the reproductive apparatus upon which they are placed, is of a much more complex structure. That of the common Mushroom (*Agaricus campestris*), (*fig.* 824),

Fig. 824.

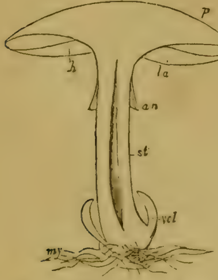


Fig. 825.

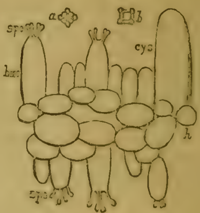


Fig. 824. Vertical section of the common Mushroom (*Agaricus campestris*). *my*. Mycelium. *vol*. Remains of volva. *st*. Stipe. *an*. Annulus. *h*. Hymenium with its lamellæ, *la*. *p*. The pileus. —— *Fig.* 825. Transverse section of portion of a lamella of *Agaricus*. *h*. Hymenium. *bas*. Basidia, each bearing at its apex four spores, *spo*. *a* and *b*. The four spores separated from the basidia. *cys*. Cystidia or sacs containing granular bodies.

may be taken as an example. The fructification is here first developed in a hollow round body, called the *volva*, which arises from the *mycelium*, *my*; as the fructification becomes matured it breaks through the volva, and the following parts may then be seen, namely, a cap-like body, called the *pileus*, *p*, placed on a stalk or *stipe*, *st*, and at the base of which are the remains of the volva, *vol*. On the under surface of the pileus a number of vertical plates or laminæ are situated, which radiate from the centre towards the circumference, these are the *lamellæ* or *gills*, *la*; they constitute collectively the *hymenium*, *h*, upon which the spores are arranged. The hymenium is at first enclosed in a membrane called the *veil* or *indusium*, but this is soon ruptured by the development of the pileus and stipe, and is either completely torn away from the latter, or, as is more commonly the case, it remains as a sort of ring or *annulus*, *an*, surrounding the upper part of the stipe.

The hymenium varies in its character and position in different genera. In some it is on the upper surface of the pileus, as in *Helvella*, instead of on the lower, as in *Agaricus*. Some-

times again the hymenium lines a number of tubes, as in *Polyporus* and *Boletus*, or a series of solid columns, as in *Hydnum*, instead of being composed of vertical radiating plates. At other times, the hymenium, instead of exposing its sporiferous membrane to the air, as in *Agaricus*, &c., is enclosed in a leathery membrane called the *peridium*, as in *Lycoperdon*. The former are called Hymenomycetous Fungi; the latter Gasteromycetous Fungi.

On the surface of certain cells of the hymenium which are called *basidia* (*fig.* 825, *bas*), the spores are situated. Each basidium commonly bears four spores, *spo*, *a* and *b*, situated on stalks or branches proceeding from it. These stalks have been termed by some *sporophores*, a name which has been also used as synonymous with *basidia*. Among the basidia of the Agarics opaque vesicles occur, which have been termed *pollinaria*, *cystidia*, or *utricles*. They appear to be *paraphyses* or abortive basidia.

All Fungi which thus bear their spores on the outside of peculiar cells or basidia, have been called *Basidiosporous* or *Acrosporous;* while those in which the spores are enclosed in thecæ or sacs, are termed *Thecasporous* or *Ascosporous*; this difference was formerly thought to constitute a firm basis for the division of the Fungi, but recent researches have shown that both *basidiospores* and *thecaspores* occur in the same species at different periods of their growth, and hence such a division must be abandoned. All the so-called Thecasporous Fungi were included by Schleiden under the class of Lichens.

We must now briefly allude to the *Thecasporous* or *Ascosporous Fungi*. The simplest form of these is seen in the Mildews. Thus in *Mucor* (*fig.* 150), *Ascophora*, &c., the spores or sporules are arranged in great numbers without any definite order, in a roundish sac called the *theca* or *ascus*, &c., placed at the end of a filament which arises from the mycelium. In the *Peziza* (*fig.* 826) and some other Fungi, the thecæ, *t*, which are more or less elongated in form, are arranged in groups in a definite order, and commonly mixed with *paraphyses*, *p*. Each theca in the latter Fungi contains four, six, or eight spores or sporules, (or, as they have been also termed, *sporidia*,) placed one above the other (*fig.* 826, *sp*).

Fig. 826.

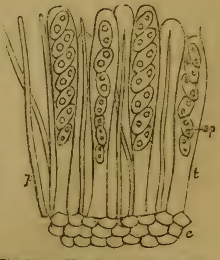


Fig. 826. Vertical section of the fructification of a Thecasporous Fungus (*Peziza*). *c*. Cellular substance from which the thecæ, *t*, arise, each of which contains spores or sporidia, *sp*. *p*. Paraphyses.

But very little is known of the *spermatia* of Fungi (*fig.* 827, *s*). They were discovered by Tulasne, and are supposed to be analogous to the sper-

matozoids of the higher cryptograms. They are sometimes enclosed in spermagonia (*Fig.* 827), like those of Lichens (p. 384). The thread-like stalks upon which the spermatia are placed have been termed *sterigmata* (*fig.* 827 *st*). Although they have been supposed to represent the male organs, yet at present the sexual nature of the Fungi is not clearly ascertained. With regard to the Fungi generally, it may be observed that our knowledge upon many points is becoming enlarged every day, so that much of what may be written now will probably soon require modification.

Fig. 827.

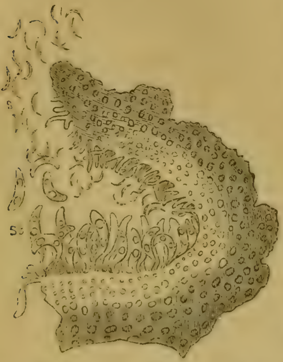


Fig. 827. Section of a spermagonium of a Fungus. After Henfrey. *s.* Spermatia. *st.* Sterigmata.

3. Algæ or Sea-weeds. — This group of plants, like the Fungi, comprises a vast number of species, which vary exceedingly in form, colour, size, and other peculiarities. They are all either inhabitants of salt or fresh water, and may be microscopic plants, or growths of enormous length. They are commonly divided into three orders, which are called respectively, *Chlorospermeæ Chlorosporeæ* or *Confervoideæ*, *Rhodospermeæ Rhodosporeæ* or *Florideæ* and *Melanospermeæ Melanosporeæ* or *Fucoideæ*. The reproductive organs of each of these orders will be very briefly described.

1. *Chlorosporeæ, Confervoideæ, or Green-coloured Algæ.* — The simplest plants of this group, as *Protococcus* (*figs.* 147 and 148), &c., consist of a single cell, so that the nutritive and reproductive processes cannot be separated; but each cell has the power of dividing by the process of cell-division into two or four new cells, from which new individuals are formed when the parent-cell bursts. In other cases, as in *Zygnema* (*fig.* 828), the cells of two filaments, *c*, *d*, unite by a lateral cellular process, *p*, by means of which their contents (*endochrome*) intermingle, and the result is the formation of a spore, *s*, capable of germinating. This process is called *conjugation*, and will be more particularly explained hereafter. In other plants of this group the spore is apparently developed without conjugation. Besides these true spores, which may be called *resting* or *inactive spores*, we have also formed in the plants of this group, as in many other Algæ, what have been called *zoospores* or *gonidia* (*fig.* 146). These are

formed apparently without any process of fertilization out of the contents of the cells, and are discharged, according to Henfrey, without any cellulose coat, but consist simply of a protoplasmic sac. They are furnished with ciliæ, by which they are enabled to move freely for some time, hence their name; but they afterwards settle down and germinate, when they also acquire a cellulose coat. The number of ciliæ varies in different plants; in some there are two (*fig.* 14), in others four (*fig.* 829), in others

Fig. 828.

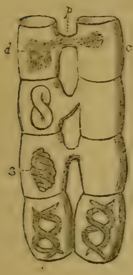


Fig. 829.

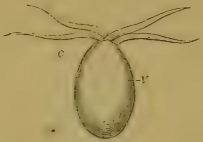


Fig. 830.

Fig. 828. Portions of two filaments of *Zygnema* conjugating. *c*, *d*. The contents (*endochrome*) of two cells mixing by means of a lateral process, *p*. *s*. Germinating spore, which results from the union and mixing of the contents. The two cells below contain spiral filaments.——*Fig.* 829. Zoospore of *Chætophora*, consisting of a cell, *v*, with four ciliæ, *c*, at its apex.——*Fig.* 830. End of a filament of *Vaucheria Ungeri*, with a single gonidium or zoospore, *g*, escaping.

there is a tuft of ciliæ at one end (*fig.* 15), while in others, again, as in *Vaucheria*, the spores are ciliated all over (*fig.* 16). They may be produced either singly in the cells, as in *Vaucheria* (*fig.* 830), or in great numbers, as in *Achlya* (*fig.* 146); and they ultimately escape by rupturing the coats of the cell in which they are contained (*figs.* 830, *g*, and 146, B).

Some Confervoids have two kinds of zoospores, which are termed respectively, *macrogonidia* and *microgonidia*; the latter are smaller and longer than the former, and are thought by some authors to resemble spermatozoids in their function.

These *zoospores* are sometimes confounded with *spermatozoids*, from which structures, however, they are quite distinct. Henfrey has thus distinguished them·—"The essential character of a zoospore is, that when separated from the parent it becomes encysted, and at once developed into a new individual resembling the parent, (certain obscure exceptions however occur, where the zoospore after germinating, at once discharges new ciliated bodies (zoospores or spermatozoids (?)). Spermatozoids are

transitory structures; when discharged from the parent-cell they either make their way to a germ-cell of a spore, fertilize it and disappear; or if debarred from this, at once perish without germination."

Besides the above-mentioned reproductive organs, there have been found in certain genera of this order — *sporangia*, in which *resting-spores* are produced by impregnation from *spermatozoids* derived from *antheridia.*

2. *Rhodosporeæ, Florideæ, or Rose-coloured Algæ.* — There appear to be three forms of reproductive structure in plants of this order of Algæ; these are termed respectively 1. *tetraspores;* 2. *spores;* and 3. *antheridia.* The tetraspore is a peculiar feature of the plants of this order, and at once distinguishes them from their allies. The sexual nature of Rhodosperms would appear to be tolerably well ascertained.

1. *Tetraspores.* — These are either naked, as in *Callithamnion*, and then either situated on the outside of the frond, or more frequently collected in masses and immersed in its substance (*fig.* 831); or they are collected together in distinct organs of varying forms, called *conceptacles* (*fig.* 832), and *stichidia* (*fig.* 833). The tetraspore consists of a more or less globular transparent sac or cell, called the *perispore*, which when mature contains within it four, (or rarely three), sporules (*fig.* 831). The occurrence of three sporules was formerly considered to be tolerably frequent, but this is now known to be an error; the fourth sporule is however occasionally suppressed, as in *Lepidostrobus*, as first shown by Mr. Brown. The tetraspores are regarded by Harvey and some other authors, as analogous to *gonidia.*

2. *The Spores*, like the tetraspores, vary in their situation. Sometimes they are collected together in masses without any special sac; but generally they are situated in distinct hollow *conceptacles*, which have received different names, according to their structure and arrangement; the terms *favellæ* (*fig.* 834), *ceramidium* (*fig.* 835), and *coccidium* are those which are most in use. The spores are generally formed by the transformation of the cells of articulated threads, situated commonly in the conceptacles. They consist of at least two coats of a somewhat gelatinous nature, enclosing a dense clustered granular mass.

3. *The Antheridia.* — But little is known of the structure of the antheridia of this order of Algæ. They are collections of little cells of various forms, and variously arranged, in each of which a peculiar body, called a *spermatozoid*, is ultimately formed. According to Berkley, "the spermatozoids vary a little in shape. Derbès and Solier figure many of them with a delicate appendage; but Thuret has in vain sought for such an appearance. There can, however, be little doubt but that they are truly impregnatory organs. The flagelliform appendage cannot certainly

Fig. 831.

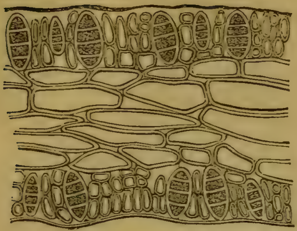


Fig. 832.

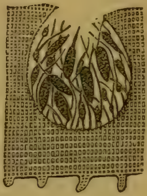


Fig. 833.

Fig. 834.

Fig. 835.

Fig. 831. Section of the frond of *Rhynchococcus coronopifolius*, with tetraspores immersed in its substance. After Henfrey.——*Fig.* 832. Section of a conceptacle of *Hildenbrandtia sanguinea*, containing tetraspores. After Henfrey.——*Fig.* 833. Stichidium of *Dasya Kutzingiana*, containing tetraspores. After Henfrey.——*Fig.* 834. Two *favellæ* of *Callithamnion tetragonum*, containing spores.——*Fig.* 835. *Ceramidium* of *Bonnemaisonia asparagoides*, containing spores, and terminated by a pore.

be considered as essential to their functions."—(Berkley's "Introduction to Cryptogamic Botany," p. 199.)

Zoospores have not at present been found in the Rhodospermous division of the Algæ.

3. *Melanosporeæ, Fucoideæ, or Brown-coloured Algæ.*—The sexual nature of these Algæ is generally considered established, and they are even described by some authors, as Berkley, as monœcious or diœcious.

In these Algæ, as in the Rhodospermous division, the reproductive organs seem to be of three kinds:—namely, 1. *zoospores;* 2. *spores;* and 3. *antheridia.*

1. The *zoospores* are found either in large numbers, in peculiar cells called *oosporangia*, *sporangia*, or commonly *spores*, which are placed at the articulations (*fig.* 836), or summits of the divisions of the frond; or singly, in each cell of a jointed thread-like body, which has been called the *trichosporangium*. These zoospores have essentially the same structure as those previously described in plants of the order Chlorospermeæ; that is, when discharged from their sacs they have no cellulose coat, but consist merely of

Fig. 836.

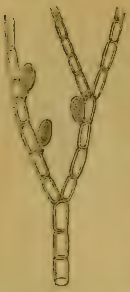


Fig. 836. Portion of a filament of *Ectocarpus verminosus*, bearing lateral *oosporangia* or *spores*; the contents are termed zoospores. After Henfrey.

a protoplasmic sac, and furnished with ciliæ, by which they actively move for some time; they then become immovable, acquire a cellulose coat, and germinate. The zoospores of the trichosporangia appear to be closely allied to the spermatozoids. The zoospores are of an olive-brown colour, somewhat pear-shaped, and have but two ciliæ of unequal length diverging from each other.

2. The *Spores*, or inactive spores as they may be called in contradistinction to the zoospores, on account of their being motionless, are situated in sacs called sporangia (*fig.* 837, *sp*) or *perispores*. In rare cases but one spore is contained in each sporangium or perispore, as in *Halidrys*, but generally the endochrome or contents of the sporangium divides in such a manner, as to form two, four, or eight spores or sporules, each of which is capable of germinating. Besides the perispore, the spores are also enclosed in two other membranes, one situated directly within it, called the *epispore*, and a third internal to the latter. These sporangia are either dispersed all over the surface of the frond; or they are collected in definite groups called *sori* on its surface; or on the walls of globose cavities called *conceptacles* or *scaphidia* (*fig.* 837), which communicate with the external sur-

Fig. 837.

Fig. 838.

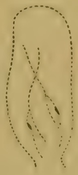


Fig. 839.

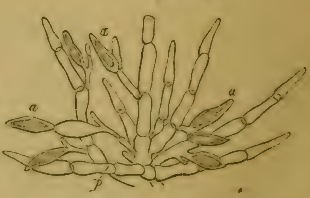


Fig. 837. Section of a conceptacle of *Fucus canaliculatus*, containing sporangia, *sp.*; antheridia; and paraphyses, *par.* *s.* Opening by which the spores escape. After Henfrey.——*Fig.* 838. Antheridium of *Fucus serratus*, with two ciliated *phytozoa* or *spermatozoids* in its interior.——*Fig.* 839. Filamentous cellular bodies, from the inner surface of a conceptacle, bearing antheridia, *a. a. a.* *p.* Paraphyses or abortive filaments.

face by a pore, *s.* These conceptacles are usually grouped together in somewhat club-shaped or oval *receptacles*, situated at the summit or side of the frond or its divisions (*fig.* 153, *t*).

3. The *Antheridia* are little, usually somewhat ovate sacs

(*fig.* 839, *a*), attached to delicate jointed filaments arising from the inner surface of the *conceptacle* (*fig.* 837). The antheridia may either occur in the same conceptacles with the sporangia, or in different ones, and then either on the same, or on distinct individuals. When conceptacles of both kinds occur on the same plant, this is termed *monœcious*, if on different plants, they are *diœcious*. By some algologists, the plants are termed *hermaphrodite* when both antheridia and sporangia occur in the same conceptacle. The delicate jointed filaments which in all cases surround the sporangia, but upon which no antheridia are found, are termed paraphyses (*fig.* 839, *p*). The antheridium contains a number of *spermatozoids, antherozoids*, or *phytozoa*, of various shapes, each of which is furnished with two ciliæ of unequal length (*fig.* 838). Thuret has clearly proved the existence of sexes in this family of the Algæ.

BOOK II.

SYSTEMATIC BOTANY, OR THE CLASSIFICATION OF PLANTS.

CHAPTER 1.

GENERAL PRINCIPLES OF CLASSIFICATION.

Our attention has been hitherto directed to the examination of the structure of the various parts and organs of plants. In doing so, we cannot but have noticed the almost infinite varieties of forms which have thus been presented to us, and also at the same time observed that, notwithstanding such variations, there are some striking resemblances in the structure of the organs of certain plants, by which a close relationship is thus clearly indicated between them. It is the object of Systematic Botany to take notice of such relationships, and thus to bring plants together which are allied in their structure, and to separate those that are unlike; and in this way to take a comprehensive view of the whole Vegetable Kingdom. In its extended sense, Systematic Botany has for its object, the naming, describing, and arranging of plants in such a manner, that we may readily ascertain their names, and at the same time get an insight into their relations and general properties.

At the present time there are probably about 125,000 species of plants known to exist on the earth. It is absolutely necessary therefore, for the purpose of study, or in order to obtain any satisfactory knowledge of such a vast number of individuals, that we should arrange them according to some definite and fixed rules. Before we proceed to describe the systems that have been devised at various times for their arrangement, it will be necessary for us to define certain terms which are in common use in such systems.

1. Species. — By the term species we understand a collection of individuals which resemble each other more nearly than they resemble any other plants, and which can be reproduced by seed; so that we may from analogy infer that they have all

issued originally from one common stock. Thus if we walk into a field of Wheat, Barley, or Oats, we observe thousands of individuals, which, although differing to a certain extent in size, and in some other unimportant characters, we at once associate together under a common name. In like manner we commonly observe around us, in the gardens and fields, similar collections of individuals. Such collections of plants, thus seen to resemble each other in all their important parts, constitute our first idea of a species; and that idea is at once confirmed if, by taking the seeds of such plants and sowing them, we obtain other plants resembling those from which such seeds have been obtained.

Varieties. — It has just been observed, that if the seed of a species be sown it will produce a plant resembling its parent more than it will resemble any other individual. This will, however, only happen, when the new individual has been exposed to similar influences of soil, heat, light, moisture, &c., as its parent; and hence we find that any variations in these particulars will lead to certain peculiarities in form, colour, size, and other minor characters, in plants raised from the seeds of the same species. In this manner we have formed what are termed *varieties.* In some cases such variations are merely transient, and the individuals presenting such peculiarities will in time return to the original specific type, or perish altogether; while in other instances they are permanent and continue throughout the life of the individual, the whole plant being, as it were, impregnated with the particular variations thus impressed upon it, and hence such variations may be perpetuated by the gardener in the operations of Budding, Grafting, &c. (see Budding, &c.), as is the case with many of our fruit trees and flowers. Even these varieties, however, cannot be propagated by seed, for if their seeds be sown, the individuals which will be produced will have a tendency to revert to the original species from which such varieties have been obtained, so that the nature of the plant raised will depend chiefly upon that of the soil, &c., in which it is placed. Thus, if we sow the seeds of a number of different kinds of Apples, the fruit which will be afterwards produced by the new generation of Apple trees, will, instead of resembling that of their parents, have a tendency to revert to that of the Common Crab, from which species all such variations have been originally derived. Hence a variety differs from a species in the fact that it cannot be propagated by seed.

Races. — Besides the varieties just alluded to there are others, which are called *permanent varieties* or *races*, because their peculiarities can be transmitted by seed. Familiar examples of such races are afforded by our Cereal grains, as Wheat, Oats, Barley, &c., and also by our culinary vegetables, as Peas, Lettuce, Radishes, Cabbages, Cauliflower, Broccoli, &c. Similar permanent varieties occur in the Animal Kingdom

and may be illustrated by the different races of mankind now existing in different parts of the earth, all of which have, as we know, sprung from a single pair of individuals. How such races of plants have originated, it is impossible to say with any certainty. In the first case such races probably arose in an accidental manner, for it is found that plants under cultivation are liable to produce certain variations or abnormal deviations from their specific type, or to *sport*, as it is termed. By further cultivation under the care of the gardener, such variations are after a time rendered permanent, and can be propagated by seed. Such permanent varieties however, if left to themselves, or if sown in poor soil, will soon lose their peculiarities, and either perish or return to their original specific type; such races therefore present well-marked characters by which they are distinguished from true species. Hence, although our cereal grains and culinary vegetables, &c., have become permanent varieties by ages of cultivation and by the skill of the cultivator, they can only be made to continue in that state by a resort to the same means, for if left to themselves they would, as just observed, either perish or revert to their original specific type; and hence we see also, how important is the assistance of the agriculturist and gardener in perpetuating and improving such variations.

Another cause, which leads to constant variations from the specific type, is *hybridization*. (See Hybridization.) The varieties thus formed, which are called *hybrids* or *cross-breeds*, are however, rarely transmitted by seed — although, in some instances, such is the case for a few generations — but they gradually revert to one or the other parent stock.

We have now seen that species, under certain circumstances, are liable to variations, but that all such varieties have a tendency to revert to their original specific type. Hence species must be considered as permanent productions of Nature, which are capable of varying within certain limits, but in no cases capable of being altered so as to assume the characters of another species.*

* The above views as to the nature of species and varieties are those most commonly entertained by naturalists, but they are altogether opposed to those recently brought forward by Darwin and Wallace, and which have been fully and most ably developed in a work by the former, "On the Origin of Species." These authors contend, that species, so far from being immutable, are liable to change of almost any extent, — in fact, that plants by the operation of causes acting over a long period of time, may become so altered, that they preserve scarcely any apparent resemblance to those from which they sprung. At present, however, although fully admitting the very great ability with which these opinions have been supported, we must, until further

There is not the slightest foundation for the theory, which has been advocated by some naturalists, of a transmutation of species. All such statements therefore, that have been made, of the conversion of Oats into Rye, or of any species whatever into another, are entirely without foundation, and have arisen from imperfect observation. A case, showing the importance of carefully investigating such supposed transmutations, has been recorded in the *Gardener's Chronicle* for October 6, 1849. A spikelet of Oats was seen to come out from a head of Wheat. On examination it appeared that the stalk of the Oat had twisted itself round the ear of Wheat when both were very young, and they had grown up together in close apposition, the chaff of the Wheat completely hiding the stalk of the Oat, which was at last, by some accident or violence, snapped from its parent and left clinging to its supporter, all trace of its origin being hidden.

In practice it is very important that we should distinguish all the above varieties from true species, for nothing is so calculated to lead to confusion in descriptive botany as the raising of mere varieties to the condition of species. No individuals should be considered as constituting a species unless they exhibit important and permanent distinctive characters in a wild state, and which can be perpetuated by seed. Great uncertainty still prevails in our systematic works as to what is a species and what is a variety; and hence we find different authors, who have written on British and other plants, estimate the number of species contained in such genera as Rosa, Rubus, Saxifraga, Hieracium, Salix, Smilax, &c., very differently.

2. Genera.—The most superficial observer of plants will have noticed that, certain species are more nearly allied to each other than to other species. Thus, the different kinds of Roses, Brambles, Heaths, Willows, may be cited as familiar examples of such assemblages of species; for, although the plants comprehended under these names present certain well-marked distinctive characters, yet there are at the same time also, striking resemblances between them. Such assemblages of species are called *genera*. A *genus*, therefore, is a collection of species which resemble one another in general structure and appearance more than they resemble any other species. Thus, the various kinds of Brambles constitute one genus, the Roses another, the Willows, Heaths, Clovers, Oaks, &c., form also, in like manner, as many different genera. The characters of a genus are taken exclusively from the organs of reproduction, while those of a species are derived generally from all parts of the plant. Hence a genus might be defined as a collection of species which re-

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evidence be adduced, adhere to the views above expressed, as to the nature of species and varieties.

semble one another in the structure and general characters of their organs of reproduction. It does not necessarily happen that a genus should contain a number of species, for, if a single one presents peculiarities of a marked kind, it may of itself constitute a genus.

It frequently happens that, two or more species of a genus have a more striking resemblance to each other in certain important characters than to other species of the same genus; in which case they are grouped together under the name of a *sub-genus.*

3. ORDERS OR FAMILIES.—If we regard collections of genera in the same point of view as we have just done those of species,—that is, as to their resemblance or family likeness,—we shall find that some of them also resemble one another more than they do others. Thus Mustards, Turnips, Radishes, and Cabbages, have a strong common resemblance, while they are unlike Strawberries and Brambles; and even less so to Hazels, Oaks, and Beeches; and still more unlike Larches, Pines, Firs, and Cedars. Proceeding in this way throughout the vegetable kingdom, we collect together allied genera, and form them into groups of a higher order called *Orders* or *Families;* hence, while genera are collections of related species, orders are collections of allied genera. Thus Mustards, Turnips, Radishes, Cabbages, all belong to different genera, but they all agree in their general structure, and are hence included in the order Cruciferæ; while Strawberries, Brambles, Cinquefoils, Roses, Apples, Plums, Almonds, are all different genera, but from the general resemblance they bear to one another in their structure, they are placed in one order, called Rosaceæ. Again, Oaks, Beeches, and Hazels, are different genera, but they belong to one order; also the Larches, Pines, and Cypresses, are different genera, but they all have a fruit called a *cone,* and are hence placed in one order, the Coniferæ.

We find also that certain genera of an order, like certain species of a genus, have a more striking resemblance to one another than to other genera of the same order; hence such are grouped together into what are called *Sub-orders.* Thus the Chicory, Dandelion, Sowthistle, Lettuce, Thistle, Burdock, Chamomile, Ox-eye, all belong to the same order, but there is a greater resemblance in the Chicory, Dandelion, Sowthistle, and Lettuce, to one another, than to the remaining genera; while of those again the Thistle and Burdock are more nearly related to each other than they are to the Ox-eye and Chamomile. Hence, while all the above genera belong to the order Compositæ, they are at the same time placed in three different sub-orders. Thus the sub-order Cichoraceæ includes the Chicory, Dandelion, Sowthistle, and Lettuce; the sub-order Cynarocephalæ includes the Thistle and the Burdock; and that

of Corymbiferæ, the Ox-eye and Chamomile. In like manner, while we find the Almond, Cherry, Strawberry, Raspberry, Rose, and Apple, all belonging to the same order Rosaceæ, yet some of them have more resemblance than others. Thus the Almond and Cherry have a drupaceous fruit, and belong to a distinct sub-order, Amygdaleæ; the Strawberry and Raspberry are much more alike each other than they are to the Almond and Cherry, or to the Rose and Apple, hence they are placed in a sub-order called Potentilleæ; while the Apple again is very different to the Rose, and both are unlike in certain respects to the other genera of the two sub-orders just mentioned, and hence the Apple is placed in the sub-order Pomeæ, and the Rose that of Roseæ.

It is found convenient at times to subdivide sub-orders also into *Tribes* and *Sub-tribes*, by collecting together into groups certain very nearly allied genera, but it is not necessary for us to illustrate such divisions further, as the principles upon which they depend have been now sufficiently treated of.

4. Classes.—By a class we understand a group of orders which possess some important structural characters in common. Thus we have the classes Monocotyledones, Dicotyledones, and Acotyledones, which present certain distinctive characters in their embryos, from which they derive their names; and such classes present, moreover, other important anatomical differences.

The Classes are again subdivided into sub-classes and other divisions, in the same manner as the orders are thus subdivided; but as such divisions vary in different systems, and are all more or less artificial, it is not necessary to dwell upon them further. The more important divisions of plants, and those which are found in all systems of classification, are Classes, Orders, Genera, and Species.

The following table will include all the groups we have alluded to; the more important and those of universal use being indicated by a larger type.

1. CLASSES.
   - Sub-classes.
   2. ORDERS OR FAMILIES.
      - Sub-orders.
        - Tribes.
          - Sub-tribes.
      3. GENERA.
         - Sub-genera.
         4. SPECIES.
            - Varieties.
              - Races or Permanent Varieties.

Henslow has taken as an illustration of these different divisions *Anthyllis Vulneraria*, thus: —

1. CLASS	*Dicotyledones.*
Sub-class	*Calyciflorœ.*
2. ORDER	*Leguminosœ.*
Sub-order	*Papilionaceœ.*
Tribe	*Loteœ.*
Sub-tribe	*Genisteœ.*
3. GENUS	*Anthyllis.*
Sub-genus or Section . . .	*Vulneraria.*
4. SPECIES	*Vulneraria.*
Variety	*Dillenii.*
Race	*Floribus coccineis.*
Variation	*Foliis hirsutissimis.*

CHARACTERS.—By the term character, we mean a list of all the points by which any particular *variety*, *species*, *genus*, *sub-order*, *order*, *sub-class*, or *class*, is distinguished from another. We have also two kinds of characters, which are called, respectively, *essential* and *natural*. By an essential character, we understand an enumeration of those points only by which any division of plants may be distinguished from others of the same nature; such may be also called *diagnostic* characters. A *natural character*, on the other hand, is a complete description of a given species, genus, order, or class, including an account of every organ from the root upwards, through the stem, leaves, flowers, fruit, and seed. Such characters are necessarily of great length, and are not required for general diagnosis, although of great value when a complete history of a plant or group is required. Those characters again, which refer to a species, are called *specific*, and are taken generally from all the organs of the plant, and relate chiefly to their *form*, *surface*, *division*, *colour*, *dimension*, and *duration*, or to characters of a superficial nature, and without reference to internal structure The characters of a genus are called *generic*, and are taken from the organs of reproduction. The characters of an order are termed *ordinal*, and are derived from the general structure of the plants in such groups, more especially of the organs of reproduction; while the characters of a class, as already mentioned, are derived from certain important anatomical peculiarities which the plants of such divisions exhibit. The essential character of a genus, when indicated in Latin, is put in the nominative case, while that of a species is placed in the ablative.

NOMENCLATURE.—The names of the classes are derived from some important and permanent characters which they possess, relating either to their structure or mode of development. Such names vary, however, according to the views of different systematic botanists. Those more commonly used in this

country, and which have been accordingly adopted in this work, are, Acotyledones, Monocotyledones, and Dicotyledones,—terms which, as we have already explained, are derived from the structure of the embryo in the three classes respectively. Other terms also in common use, are derived from the absence or presence of a stem, and its mode of development: such are Exogens, Endogens, Acrogens, and Thallogens. The above names are used especially in what are called Natural Systems of Classification; while the names of Classes in the Artificial System of Linnæus, are derived chiefly from the number and other characters presented by the stamens (page 406).

The names of the Orders in the Artificial System of Linnæus are chiefly derived from the pistil and fruit. Those of Natural Systems are usually taken from some well-known genus which is included in any particular order, and which may be regarded as the type of that order. Thus the genus Ranunculus gives the name *Ranunculaceæ* to the order to which it belongs; the genera Papaver, Malva, Hypericum, Geranium, Rosa, Lilium, Orchis, Iris, &c., in like manner, give names respectively, to the orders *Papaveraceæ*, *Malvaceæ*, *Hypericaceæ*, *Geraniaceæ*, *Rosaceæ*, *Liliaceæ*, *Orchidaceæ*, *Iridaceæ*, &c. At other times, the names of the orders are derived from some characteristic feature which the plants included in them present. Thus the order *Cruciferæ* is so named, because the species it includes, have the four petals of their flowers arranged in a cross-like form; the order *Leguminosæ* comprises plants whose fruit is a legume; the *Umbelliferæ* are umbel-bearing plants; the *Labiatæ* have a labiate corolla; the *Coniferæ* are cone-bearing plants; and so on.

The names of genera are derived in various ways: thus either from the name of some eminent botanist, as Linnæa after Linnæus, Smithia after Smith, Hookeria after Hooker, Jussiæa after Jussieu, Tournefortia after Tournefort, &c.; or from some peculiarity of structure, or habit, and various other circumstances. Thus, *Crassula* is derived from the genus comprising plants with succulent or thickened leaves; *Dentaria* derives its name from presenting dentate roots; *Arenaria* from growing in sandy places; *Lithospermum* from its seeds or properly achænia having a stony hardness; and so on.

The names of species are also variously derived. The specific names are usually written after the generic, and these taken together constitute the proper appellation of a plant. The species of the genus *Viola*, as shown by Gray, exhibit the origin of many specific names. "Thus, specific names sometimes distinguish the country which a plant inhabits, for example, *Viola canadensis*, the Canadian Violet; or the station where it naturally grows, as *Viola palustris*, which grows in swamps, *Viola arvensis*, in fields, &c.; or they express some obvious character of the species, as *Viola rostrata*, where the corolla bears a remarkably long spur, *Viola*

tricolor, which has tricoloured flowers, *Viola rotundifolia*, with rounded leaves, *Viola lanceolata*, with lanceolate leaves, *Viola pedata*, with pedately parted leaves, *Viola primulæfolia*, where the leaves are compared to those of a Primrose, *Viola asarifolia*, where they are likened to those of *Asarum*, *Viola pubescens*, which is hairy throughout, &c. Frequently the species bears the name of its discoverer or describer, as *Viola Muhlenbergii*, *Viola Nuttalii*, &c." Specific names are written after the generic, as indicated above in the different species of the genus *Viola;* they are also commonly adjectives, and agree in gender and case with the name of the genus. When a species is named after its discoverer or describer, it is usually placed in the genitive case, as *Viola Muhlenbergii*, *V. Nuttalii*, &c.; but when such names are merely given in honour of botanists who have had nothing to do with their discovery or description, the specific names are usually put in the adjective form, as *Carex Hookeriana*, *Veronica Lindleyana:* such a rule is, however, frequently departed from. Sometimes the specific name is a noun, in which case it does not necessarily agree with the genus in gender; such specific names are often old generic ones, as *Dictamnus Fraxinella*, *Rhus Cotinus*, *Lythrum Salicaria*, *Rhus Coriaria*, *Dianthus Armeria*, *Asclepias Vincetoxicum*. In such cases the specific name should begin with a capital letter; a similar rule should also be adopted when it is derived from a person; but in all other instances the specific name should begin with a small letter. The specific name was called by Linnæus the *trivial* name; thus, in the particular kind of Violet called *Viola palustris*, *Viola* is the generic, and *palustris* the specific or trivial name.

Abbreviations and Symbols.—It is usual in botanical works to use certain abbreviations and symbols. A few of the more important can alone be mentioned here. Thus the names of authors, when of more than one syllable, are commonly abbreviated by writing the first letter or syllable, &c., as follows:—

L. or *Linn.* means Linnæus; *Juss.* is the abbreviation for Jussieu; *D. C.* or *De Cand.* for De Candolle; *Br.* for Brown; *Lindl.* for Lindley; *Rich.* for Richard; *Willd.* for Willdenow; *Hook.* for Hooker; *With.* for Withering; *Endl.* for Endlicher; *Bab.* for Babington; *Berk.* for Berkeley, &c., &c.

It is common to put such abridged names after that of the genus or species which has been described by them respectively. Thus *Eriocaulon, L.* indicates that the genus *Eriocaulon* was first described by Linnæus; *Miltonia, Lindl.* is the genus *Miltonia* as defined by Lindley; *Nuphar pumila, D. C.* is the species of *Nuphar* defined by De Candolle, &c. &c.

Other abbreviations in common use are, *Rad.* for root; *Caul.* for stem; *Fl.* for flower; *Cal.* for calyx; *Cor.* for corolla; *Per.* for perianth; *Fr.* for fruit; *Ord.* for order; *Gen.* for

genus; *Sp.* or *Spec.* for species; *Var.* for variety; *Herb.* for herbarium, &c. Again,—

V. v. c. (*Vidi vivam cultam*) indicates that the author has seen a living cultivated plant as described by him.

V. v. s. (*Vidi vivam spontaneam*) indicates that the author has seen a living wild plant.

V. s. c. (*Vidi siccam cultam*) indicates that a dried specimen of the cultivated plant has been examined.

V. s. s. (*Vidi siccam spontaneam*) indicates that a dried specimen of the wild plant has been examined.

The more important symbols are as follows:—

⊙, ○, ①, or A, signifies an annual plant.

⊙ ⊙, ②, or B, means a biennial plant.

♃, △, or P, signifies a perennial.

♄ or Sh., means a shrub.

T. signifies a tree.

(twining to the right;) twining to the left.

♂ a staminate flower.

♀ a pistillate flower.

☿ a hermaphrodite flower.

♂ - ♀ a monœcious plant.

♂ : ♀ a diœcious species.

☿ ♂ ♀ a polygamous species.

○ = signifies that the cotyledons are accumbent, and the radicle lateral.

○ || Cotyledons incumbent, radicle dorsal.

○ ≫ Cotyledons conduplicate, radicle dorsal.

○ || || Cotyledons twice folded, radicle dorsal.

○ || || || Cotyledons three times folded, radicle dorsal.

? The note of interrogation is used to indicate doubt or uncertainty as to the genus, species, locality, &c.

! The note of exclamation indicates certainty in the above particulars.

* The asterisk indicates that a good description is to be found at the reference to which it is appended.

CHAPTER 2.

SYSTEMS OF CLASSIFICATION.

We have already stated that Systematic Botany has for its object, the naming, describing, and arranging of plants in such a manner, that we may readily ascertain those names, and get an insight into their relations and general properties. All systems that have been devised for the arrangement of plants

do not comprise all the above points; for, while some are of value simply for affording us a ready means of ascertaining their names, others not only do this, but at the same time give us a knowledge of their affinities and properties. Hence we divide the different systems of Classification under two heads; namely, Artificial and Natural, — the former only necessarily enabling us to ascertain readily the name of a particular plant, while the latter, if perfect, should comprise all the points which come within the scope of Systematic Botany. The great aim of the botanist, therefore, should be the development of a true Natural System; but, in its day, the Artificial System of Linnæus has been of great value, and even now, to those commencing the study of Botany without the aid of a teacher, it cannot but prove of essential service. Linnæus himself never devised his system with any expectation or desire of its serving more than a temporary purpose, or as an introduction to the Natural System, when the materials for its formation had been obtained. The same may be remarked of all the artificial systems that have been devised. When used in this sense, the Artificial system of Linnæus may still be used with advantage as an index to the Natural System. Its merits have been well remarked upon by the late Professor Edward Forbes in his *Inaugural Lecture on Botany, delivered in King's College, London*, as follows: — "Those who slightingly think of the Linnæan system, forget in the present to look back fully and fairly on the past. They should remind themselves of the state in which Botany was when Linnæus undertook to make its treasures consultable. The understanding of things depends greatly on the perception of their order and relations. When that order and those relations require deep study ere we can comprehend them clearly, the man who gives us a clue, however insignificant it may be in its own nature, is not only conferring on us an invaluable benefit, but endowing the despised instrument with golden value. Such a clue did Linnæus give when he put forth the artificial system. The scientific systematist, surrounded by the stores of his herbarium, should not forget that those treasures were often amassed, in the first instance, by adventurous and earnest men rendering good service by their hands and energy, as good, in its humble way, as that which he gives by his head and philosophy. It was not to be expected of such men that in the field they should occupy themselves with thoughts of arrangement or affinity; their part was to observe and select, and the guide to their observation and selection was, in most cases, no other than the Linnæan system. In the scientific hive, as in the apiary, there must be working-bees and neuters, as well as queens and drones, — it is necessary for the economy of the commonwealth. An easy means of acquiring and arranging

information is a great help to the workmen of science; and no department has gained more thereby than Botany, which, through the facilities afforded by the artificial method devised by Linnæus, has had its facts amassed in enormous quantity for the use of its more philosophic votaries, and owes its present advanced state, in a great measure, to such humble means.

"The clue to the labyrinth, then, having served such a noble purpose, becomes a consecrated object, and should rather be hung up in the temple than thrown aside with ignominy. The traveller, returning from his adventurous and perilous journey of discovery, hangs up his knapsack with affection on the wall of his study. But travellers must return to the fields if more is to be done—and so must botanists; and each must have recourse, again and again, to those helps which aided them so well in their earliest journeys."

In both artificial and natural systems, the lower divisions—namely, the genera and species, are the same, the difference between them consisting in the manner in which they are grouped into orders and classes. Thus in the Linnæan and other artificial systems, one, or at most a few characters are arbitrarily selected, and the whole plants in the Vegetable Kingdom are distributed under classes and orders according to the correspondence or difference of the several genera in such respects, no regard being had to any other characters. The plants in the classes and orders of an artificial system have, therefore, no necessary agreement with one another, except in the characters selected for convenience as the types of those divisions respectively. Hence such a system may be compared to a dictionary, in which words are arranged, for convenience of reference, in an alphabetical order, adjacent words having no necessary agreement with each other, except in commencing with the same letter. In the Natural System, on the contrary, all the characters of the genera are taken into consideration, and these are grouped together into orders which correspond in the greatest number of important characters; and these orders are again united, upon the same principles, into groups of a higher order, namely, the classes. While it must be evident, therefore, that all the knowledge we necessarily gain by an artificial system, is the name of an unknown plant; on the other hand, by the Natural System, we learn not only the name, but also its relations to the plants by which it is surrounded, and hence we get a clue to its structure, properties, and history. Thus, supposing we find a plant, and wish to ascertain its name, if we turn to the Linnæan System, and find that such a plant is the *Menyanthes trifoliata*, this name is the whole amount of the knowledge we have gained; but, by turning to the Natural System instead, and finding that our plant belongs to the order

Gentianaceæ, we ascertain at once from its affinities, that it must have the tonic and other properties which are possessed by the plants generally of that order, and, at the same time, we also learn that it accords in its structure with the same plants; and hence, by knowing the name of a plant by the Natural System, we at once learn all that is most important in its history. It is quite true that all the orders, as at present constituted, are by no means so natural as that of the Gentianaceæ, but this arises from the present imperfection of our systems, and can only be remedied as our knowledge of plants extends; even a system, devised as perfectly as possible one day, may be deficient the next, in consequence of new plants being discovered which might force us to alter our views; for at present the Floras of many regions of the globe are almost unknown. Sufficient, however, is known of plants at present for us to establish certain great divisions according to a natural method, and which after, discoveries are not likely to affect to any important extent. The present imperfections of the Natural System are, accordingly, comparatively unimportant, and will no doubt disappear as our knowledge of the Flora of the globe becomes extended.

Having now described the general characters upon which the artificial and natural systems depend, and the particular merits and disadvantages of the two classes of systems respectively, we proceed in the next place to describe more particularly the principles upon which such systems are founded, commencing with those of an artificial character.

Section 1. — Artificial Systems of Classification.

The first artificial system of any importance, of which we have any particular record, is that of Cæsalpinus in 1583. Only 1520 plants were then known, which were distributed into fifteen classes, the characters of which were chiefly derived from the fruit. The next systematic arrangement of an artificial character was that of Morison, about the year 1670. He divided plants into eighteen classes, which were constructed according to the nature of the flower and fruit, and the external appearance of the plant. The systems of Hermann, Knaut, and others, were also constructed upon somewhat similar principles, while that of Camellus was framed from the characters presented by the valves of the pericarp, and their number. In the system of Rivinus, which was promulgated in the year 1690, plants were divided into eighteen classes, which were founded entirely upon the corolla — its regularity or irregularity, and the number of its parts being taken into consideration. The system of Christian Knaut

was but a slight alteration of that of Rivinus. That of Tournefort, which was promulgated about the year 1695, was for a considerable time the favourite system of all botanists; but it was ultimately superseded by that of Linnæus. About 8000 species of plants were then known to botanists; these were distributed by Tournefort into twenty-two classes. He first divided plants into two divisions; one of which comprised *herbs* and *under-shrubs*, and the other *trees* and *shrubs;* each of these divisions was then divided into classes, which were characterised chiefly according to the form of the corolla. Many other systems were devised which were simply alterations of the foregoing, as that of Pontedera. Magnolius, however, framed a system entirely on the calyx, while Gleditsch attempted one in which the classes were founded on the situation of the stamens. All the above systems were, without doubt, useful in their day, and paved the way for those of a more comprehensive nature, such as that of Linnæus, which, being still in use to some extent requires to be particularly examined.

Linnæan System. — This celebrated system was first promulgated by Linnæus in his "Systema Naturæ," published in the year 1735. It has been somewhat altered by subsequent botanists; but, in all its essential characters, the Linnæan system, as now adopted, is the same as devised by the great Linnæus himself. In describing this system we shall adopt the arrangement of the present day.

The classes and orders in the Linnæan system are taken exclusively from the essential organs of reproduction, the sexual nature of which Linnæus had just before clearly established; hence this artificial scheme is commonly termed the Sexual System.

Classes. — In this system plants are at first divided into Flowering and Flowerless, the latter of which constitute a class by themselves, under the name of Cryptogamia; while the former, called the Phanerogamia, are divided into twenty-three classes — the characters of twenty of these depend upon the number, position, relative length, and connection of the stamens; while those of the other three are derived from the unisexual nature of their flowers. The names by which the classes are characterised are all derived from the Greek, and express their distinctive peculiarities.

The first eleven classes comprise all hermaphrodite flowers the stamens of which are all distinct from each other, and about the same length, or, at all events, neither didynamous nor tetradynamous. The individual classes are distinguished by the absolute number of such stamens, and their names are formed by the combination of the Greek numeral expressing the number, with the termination *andria* (from ἀνήρ, a man or male), in reference to their office in the process of fertilization. Thus: —

Class 1. *Monandria*, includes all such plants which have but one stamen to the flower, as *Hippuris*, *Centranthus*, &c. (*Fig.* 481.)

Class 2. *Diandria*, those plants which have two stamens in the flower, as the Ash, Lilac, Privet, &c. (*Fig.* 426.)

Class 3. *Triandria*, those with three stamens, as most Grasses, Valerian, Iris, &c. (*Fig.* 488.)

Class 4. *Tetrandria*, those with four stamens, as the Holly, Plantain, *Alchemilla*, &c. (*Fig.* 846.)

Class 5. *Pentandria*, those with five stamens, as the Cowslip, Convolvulus, Campanula, Nightshade, &c. (*Fig.* 506.) This is a very extensive class.

Class 6. *Hexandria*, those with six stamens, as the Lily Order of the Natural System, &c. (*Fig.* 510.)

Class 7. *Heptandria*, those with seven stamens, as the Horse-chestnut, *Trientalis*, &c. (*Fig.* 888.)

Class 8. *Octandria*, those with eight stamens, as the Heath, Ivy, *Paris*, &c. (*Fig.* 564.)

Class 9. *Enneandria*, those with nine stamens, as the Flowering Rush, Rhubarb, &c. (*Fig.* 575.)

Class 10. *Decandria*, those with ten stamens, as the Pink, Saxifrage, &c. (*Fig.* 872.)

Class 11. *Dodecandria*. This class includes all plants possessing the characters above described, which have flowers containing from twelve to nineteen stamens, as the Asarabacca, Mignonette, &c.

The two succeeding classes include plants with hermaphrodite flowers, having twenty or more unconnected stamens, which vary as to their mode of insertion; but the names of the classes are not here exactly descriptive. Thus:—

Class 12. *Icosandria*, (literally twenty stamens). This includes all plants which have twenty or more stamens to the flower, and inserted on the calyx or *perigynous*, as in the Rose Order, &c. (*Fig.* 448.)

Class 13. *Polyandria*, (literally many stamens), those which have twenty or more stamens inserted on the thalamus or receptacle — that is *hypogynous*; as in the Buttercup, Poppy, Anemone, &c. (*Fig.* 883.)

The characters of the two succeeding classes depend upon the relative length of the stamens, the flowers being also hermaphrodite; thus:—

Class 14. *Didynamia*, includes plants with four stamens to the flower, two of which are long and two short, — or, in other words, *didynamous*, as in the Snapdragon, Dead-nettle, &c. (*Fig.* 547.)

Class 15. *Tetradynamia*, includes plants with six stamens, of which four are long and two short — or, in other words, *tetradynamous;* as in the Wallflower and Cruciferous Plants generally. (*Fig.* 546.) This class corresponds to the natural order Cruciferæ.

The names of the two latter classes are derived from the Greek, and signify in the former class that the two longer, and in the latter that the four longer stamens, are more powerful than the shorter.

The three next classes are characterised by the connection of the stamens into one or more bundles. Their names are derived from the combination of the Greek numeral expressing the number of bundles, with the termination *adelphia* or brotherhood, which is used metaphorically for a bundle or parcel; thus: —

Class 16. *Monadelphia*, includes all plants the stamens of which are united by their filaments into one bundle or brotherhood, as in the plants of the Mallow Order, Geranium, &c. (*Fig.* 537.)

Class 17. *Diadelphia*, those with the filaments united into two bundles or brotherhoods, as in the Pea and many other Papilionaceous flowers, Fumitory, &c. (*Fig.* 540.)

Class 18. *Polyadelphia*, those with the stamens united into more than two bundles or brotherhoods, as in the St. John's-wort, Castor Oil Plant, Orange, &c. (*Figs.* 541, 542.)

In the next class the character is derived from the coherence of the anthers, and the name is derived from two Greek words, signifying to grow together; thus: —

Class 19. *Syngenesia*, includes all plants the flowers of which have their anthers united into a tube or ring, the filaments being distinct, as in all Composite Plants. (*Fig.* 536.)

The character of the next class is founded on the union of the stamens to the pistil.

Class 20. *Gynandria*. This includes all plants in which the stamens and pistil are united together into one column, as in the Orchis Order, &c. (*Fig.* 534.)

The name of this class is derived from two Greek words, one of which *gynia*, in combination *gyn*, is used metaphorically for pistil, and the other, *andria*, as already mentioned, means male or stamen.

In the preceding twenty classes the flowers all contain both stamens and pistil. In the three following classes the stamens

and pistil are in separate flowers, either on the same plant, or on two or more different plants of the same species; thus:—

Class 21. *Monœcia*, includes plants where the stamens and pistil are in separate flowers, but on the *same* individual, as in the Euphorbia, Oak, Arum, &c. (*Fig.* 488.) The name is derived from the Greek, and signifies *one household.*

Class 22. *Diœcia*, includes plants in which the stamens and pistil are in separate flowers, situated on *different* individuals of the same species, as in the Willow, Hop, Hemp, &c. (*Figs.* 392, 393.) The name signifies literally *two households.*

Class 23. *Polygamia*, includes plants which have stamens and pistil, separate in some flowers and united in others, either on the same or on two or three different individuals of the same species, as in some Palms, &c. (*Fig.* 394.) The name is derived from the Greek, and signifies *many marriages.*

The last class includes all Flowerless Plants, in which the essential organs are said to be concealed; hence its name Cryptogamia.

Class 24. *Cryptogamia.* This includes the Ferns (*Figs.* 158, 159), Mosses (*Figs.* 154, 155), Liverworts (*Figs.* 808 & 810). Lichens, (*Figs.* 818, 819), Fungi (*Figs.* 150—152), and Algæ (*Fig.* 153), all of which are flowerless, and have concealed organs of reproduction.

Orders.—The above Classes are subdivided into Orders as follows:—

The orders in the first thirteen classes, from Monandria to Polyandria, are founded on the number of styles, or of the stigmas if the styles are absent. Their names are derived from a combination of a Greek numeral with the termination *gynia*, meaning woman or female, and which is used metaphorically for pistil, in allusion to its functions in the process of fertilization. Thus:—

Order 1. *Monogynia*, includes all plants of any of the first thirteen classes, which have but one style to each flower, as the Privet, Speedwell, Primrose, *Arbutus*, &c. (*Fig.* 567.)

Order 2. *Digynia*, includes those with two styles, as in most Grasses, *Dianthus*, &c. (*Fig.* 587.)

Order 3. *Trigynia*, includes those with three styles, as *Silene*, *Rumex*, &c. (*Fig.* 636.)

Order 4. *Tetragynia*, those with four styles, as the Holly, *Sagina*, *Radiola*, &c.

Order 5. *Pentagynia*, those with five styles, as Flax, Hellebore, Columbine, Larkspur, Monkshood, &c. (*Fig.* 427.)

Order 6. *Hexagynia*, those with six styles, as *Actinocarpus*, *Butomus*, *Drosera*, &c. (*Fig.* 577.)

Order 7. *Heptagynia*, those with seven styles. No examples among British Plants.

Order 8. *Octogynia*, those with eight styles. No examples among British Plants.

Order 9. *Enneagynia*, those with nine styles. No examples among British Plants.

Order 10. *Decagynia*, those with ten styles. No examples among British Plants.

Order 11. *Dodecagynia*, those with eleven or twelve styles, as in the common House-leek.

Order 12. *Polygynia*, those with more than twelve styles, as in the Rose, Buttercup, Strawberry, Anemone, Clematis, &c. (*Fig.* 590.)

The 14th Class, *Didynamia*, is divided into two orders, the characters of which are derived from the structure of the seed-vessel, namely:

Order 1. *Gymnospermia*. This term is derived from the Greek, and signifies *naked seeds*, because the single-seeded fruits were mistaken by Linnæus for seeds. This order includes those plants in which the fruit consists of achænia, of which there are commonly four, as in the Dead Nettle, and other Labiate Plants. (*Fig.* 594, 595.)

Order 2. *Angiospermia*. This includes those plants in which numerous seeds are enclosed in an evident seed-vessel or pericarp, which is commonly two-celled, as in the Foxglove, Snapdragon, &c. (*Figs.* 611 & 693). The name is derived from the Greek, and means *seeds in a vessel.*

The 15th Class, *Tetradynamia*, is also divided into two orders, which are in like manner characterised by the fruit: —

Order 1. *Siliculosa;* the fruit a Silicula or short pod, as in the Shepherd's Purse, Sea Kale, Scurvy-grass, &c. (*Fig.* 864.)

Order 2. *Siliquosa;* the fruit a Siliqua or long pod, as in Mustard, Stock, Wallflower, &c. (*Fig.* 666.)

The orders of the 16th, 17th, and 18th Classes are distinguished by the number of stamens, and have names, therefore,

similar to the first thirteen Classes. The number of stamens is, however, never less than three. Thus:—

Order 1. *Triandria*, with three stamens, as in Tamarind, &c.
Order 2. *Pentandria*, with five stamens, as in *Erodium*, *Passiflora*.
Order 3. *Hexandria*, with six stamens, as in Fumitory.
Order 4. *Heptandria*, with seven stamens, as in *Pelargonium*.
Order 5. *Octandria*, with eight stamens, as in *Polygala*.
Order 6. *Decandria*, with ten stamens, as in the Pea, Vetch, and many other Papilionaceous flowers.
Order 7. *Dodecandria*, with twelve to nineteen stamens, as in the Orange, &c.
Order 8. *Polyandria*, with twenty or more stamens, as in the Mallow, St John's-wort, &c.

In the 19th Class, *Syngenesia*, we have five orders. The flowers in all are compound. By Linnæus a sixth order was included in this class, under the name of Monogamia, which embraced all solitary flowers that had united anthers, as Lobelia, Violet, &c.; but this order was afterwards abolished, so that the class Syngenesia, as it now stands, is essentially a natural one, and corresponds to the order Compositæ of the Natural Systems. The names and characters of the orders are as follows:—

Order 1. *Polygamia æqualis*. This includes all plants in which the flowers or florets of the capitula are all perfect or hermaphrodite, as in Lettuce, Chicory, Dandelion, &c.
Order 2. *Polygamia superflua*, where the florets of the disk or centre of the capitula are hermaphrodite, and those of the ray or of the margin are pistillate, as in the Daisy, Elecampane, Chamomile, &c.
Order 3. *Polygamia frustranea*, where the florets of the disk are hermaphrodite, while those of the ray are neuter, as in *Centaurea*, the only British genus which presents this structure.
Order 4. *Polygamia necessaria*, where the florets of the disk are staminate and sterile, while those of the ray are pistillate and fertile, as in the Marigold (*Calendula*).
Order 5. *Polygamia segregata*, where each flower or floret of the capitulum has an involucre of its own, as in the Globe-thistle (*Echinops*). The last two orders do not include any British Plants.

The Orders in the 20th, 21st, and 22nd Classes, are founded on the number and union of the stamens; as such characters

are not taken into consideration in the definition of those Classes. Thus: —

Order 1. *Monandria*, with one stamen, as in the genus *Orchis*, and many other Orchidaceous Plants.
Order 2. *Diandria*, with two stamens, as in the Venus' Slipper (*Cypripedium*).
Order 3. *Triandria*, with three stamens, as in the plants of the genus *Carex*, *Typha*, &c.
Order 4. *Tetrandria*, with four stamens, as in the Box, Alder, Nettle, &c.
Order 5. *Pentandria*, with five stamens, as in the common Hop, Bryony (*Bryonia*), &c.
Order 6. *Hexandria*, with six stamens, as in the Birthwort, Black Bryony (*Tamus*), &c.
Order 7. *Octandria*, with eight stamens, as in the Poplar.
Order 8. *Enneandria*, with nine stamens, as in *Mercurialis*, Frog-bit, &c.
Order 9. *Decandria*, with ten stamens.
Order 10. *Dodecandria*, with twelve stamens, as *Stratiotes*.
Order 11. *Polyandria*, with numerous stamens, as in *Poterium*, *Sagittaria*, &c.
Order 12. *Monadelphia*, with the stamens united into one bundle, as in the Yew, Juniper, Fir, &c.
Order 13. *Polyadelphia*, with the stamens in several bundles, as in the Castor Oil Plant.

The Orders in the 23rd Class, *Polygamia*, are three, namely:

Order 1. *Monœcia*, with staminate, pistillate, and hermaphrodite flowers on the same plant, as in *Atriplex*, the only British genus comprised in this Class.
Order 2. *Diœcia*, with hermaphrodite flowers on one plant. and staminate and pistillate flowers on another plant, as in *Hippophaë*.
Order 3. *Triœcia*, where one plant bears hermaphrodite, another staminate, and a third pistillate flowers.

The Orders of the 24th Class, *Cryptogamia*, are natural, and will be described under their respective heads in treating of the Natural System. They are:—

Order 1. *Filices*, the Ferns. (*Figs.* 158, 159.)
Order 2. *Musci*, the Mosses. (*Figs.* 154, 155.)
Order 3. *Hepaticæ*, the Liverworts. (*Figs.* 808, 810.)
Order 4. *Lichens*, the Lichens. (*Figs.* 818, 819.)
Order 5. *Fungi*, the Mushrooms. (*Figs.* 150—152.)
Order 6. *Algæ*, the Seaweeds. (*Fig.* 153.)

The following table of the Classes and Orders of the Linnæan System, will show at a glance their distinctive peculiarities.

TABULAR VIEW OF THE LINNÆAN ARTIFICIAL SYSTEM.

					Classes.	Orders.
Stamens and pistils in the same flower.	Stamens separate from the pistils.	Stamens not connected with each other.	Stamens of equal length, or at all events neither didynamous nor tetradynamous.	1 Stamen . . .	1. MONANDRIA.	1. MONOGYNIA, 1 free style.
				2 Stamens . . .	2. DIANDRIA.	2. DIGYNIA, 2 free styles.
				3 ,, . . .	3. TRIANDRIA.	3. TRIGYNIA, 3 ,,
				4 ,, . . .	4. TETRANDRIA.	4. TETRAGYNIA, 4 ,,
				5 ,, . . .	5. PENTANDRIA.	5. PENTAGYNIA, 5 ,,
				6 ,, . . .	6. HEXANDRIA.	6. HEXAGYNIA, 6 ,,
				7 ,, . . .	7. HEPTANDRIA.	7. HEPTAGYNIA, 7 ,,
				8 ,, . . .	8. OCTANDRIA.	8. OCTOGYNIA, 8 ,,
				9 ,, . . .	9. ENNEANDRIA.	9. ENNEAGYNIA, 9 ,,
				10 ,, . . .	10. DECANDRIA.	10. DECAGYNIA, 10 ,,
				12 to 19 ,, . . .	11. DODECANDRIA.	11. DODECAGYNIA, 12 to 19 ,,
				20 or more, perigynous	12. ICOSANDRIA.	12. POLYGYNIA, 20 or more ,,
				20 or more, hypogynous	13. POLYANDRIA.	
			Of unequal length.	Two long and two short stamens.	14. DIDYNAMIA.	1. GYMNOSPERMIA, Fruit achænia. 2. ANGIOSPERMIA, Fruit capsular with many seeds.
				Four long and two short stamens.	15. TETRADYNAMIA.	1. SILICULOSA, Fruit a Silicula. 2. SILIQUOSA, Fruit a Siliqua.
		Connected with each other		By their filaments in one set.	16. MONADELPHIA.	1. TRIANDRIA, 3 stamens.
				By their filaments in two sets.	17. DIADELPHIA.	2. PENTANDRIA, 5 stamens.
				By their filaments in more than two sets.	18. POLYADELPHIA.	3. HEXANDRIA, 6 stamens. &c., &c., as in first thirteen classes.
				By their anthers .	19. SYNGENESIA.	1. POLYGAMIA ÆQUALIS. Flower in capitula, and all perfect. 2. POLYGAMIA SUPERFLUA. Flowers in capitula; florets of the disk hermaphrodite, of the ray pistillate. 3. POLYGAMIA FRUSTANEA. Flowers in capitula; florets of the disk hermaphrodite, of the ray neutral.

Plants having Stamens and pistils evident.	Stamens adherent to the pistil	20. GYNANDRIA.	4 POLYGAMIA NECESSARIA. Flowers in capitula; florets of the disk staminate, of the ray pistillate. 5 POLYGAMIA SEGREGATA. Flowers in capitula, each floret with a separate involucre. 1. MONANDRIA, stamen. 2. DIANDRIA, 2 stamens; and so on according to the number of stamens as in the first 13 classes.
	In separate flowers . On the same plant . .	21. MONŒCIA.	1. MONANDRIA, 1stamen. 2. DIANDRIA, 2 stamens. 3. HEXANDRIA, 6 stamens. 4. POLYANDRIA, numerous stamens; and so on as in the first 13 Classes. 5. MONADELPHIA, stamens in one bundle. 6. POLYADELPHIA, stamens in several bundles.
	On separate plants .	22. DIŒCIA.	
	Stamens and pistils separate in some flowers, and united in others, either on the same or on two or three different plants.	23. POLYGAMIA.	1. MONŒCIA, with staminate, pistillate, and hermaphrodite flowers on the same plant. 2. DIŒCIA. With hermaphrodite flowers on one plant, and staminate and pistillate flowers on another. 3. TRIŒCIA, where one plant bears hermaphrodite, another staminate, and a third pistillate flowers.
Plants with organs of reproduction concealed or inconspicuous . .		24. CRYPTOGAMIA.	1. FILICES. Ferns. 2. MUSCI. Mosses. 3. HEPATICÆ. Liverworts. 4. LICHENES. Lichens. 5. FUNGI. Mushrooms. 6. ALGÆ. Seaweeds.

Section 2.—Natural Systems of Classification.

The object of all natural systems, as already noticed (see page 405), is to group together those plants which correspond in the greatest number of important characters, and to separate those that are unlike. The mode in which this has been attempted to be carried out, varies according to the particular views of botanists as to the relative value of the characters furnished by the different organs of plants; hence it will be necessary for us, before proceeding to describe the more important natural systems, to make some remarks upon this subject. The observations of Dr. Lindley upon this head are so much to the point, that we cannot do better than quote them, although it will be afterwards seen, that we venture, in accordance with the views of many other botanists, to differ in some particulars from that celebrated systematist.

"The only intelligible principle by which to estimate the respective value of the characters furnished by the different organs is according to their known physiological importance; regarding those organs of the highest rank which are most essential to the life of the plant itself; placing next in order those with which the plant cannot dispense if its race is to be preserved; assigning a still lower station to such organs as may be absent without considerable disturbance of the ordinary functions of life; and fixing at the bottom of the scale those parts, or modifications of parts, which may be regarded as accessory, or quite unconnected with obviously important functions.

"The first office which all organised beings have to perform is that of feeding, for it is thus only that their existence is maintained. The second is that of propagating, by means of which their species is perpetuated. These being functions of the highest importance, it is reasonable to conclude that the organs provided for their proper execution must be of the highest importance also, and hence that they are, beyond all others, valuable for the purposes of classification. And, again, because the power of feeding must come before that of propagating, it might be conjectured beforehand, that the organs destined for the former operation would afford the first elements of a natural method. But since the act of feeding is very simple in the Vegetable Kingdom, because of the similar modes of life observable among plants, while, on the contrary, the act of propagation is highly diversified, on account of the very varied nature or structure of the parts by which it is accomplished; so might we conjecture that the organs of nutrition would afford but few distinctions available for purposes of

classification, while those of fructification would furnish many; and such is the fact Hence it is that the great classes of plants are principally distinguished by their organs of growth, and that in the numerous minor groups such peculiarities are comparatively disregarded, their chief distinctions being derived from their parts of reproduction."

Taking these principles as our guide, we should regard the structure of the embryo as of the first importance, as it contains within itself in a rudimentary condition all the essential organs of a plant. Hence, according to its presence or absence, we divide plants into two great divisions, called Cotyledonous and Acotyledonous; the former being propagated by true seeds, in which the embryo possesses one or more cotyledons, a radicle, and a plumule; while the latter are propagated by spores, in which we can discover no such distinction of parts. As Cotyledonous Plants vary in the number of their cotyledons, these may be again divided into two classes—those possessing one cotyledon being called Monocotyledonous, those with two Dicotyledonous.

Next in value to the embryo, is the growth and internal structure of the axis. Thus, the mode in which the root is produced, furnishes us with three characters, called respectively, Heterorhizal, Endorhizal, and Exorhizal. The growth and internal structure of the stem also supplies us with three characters, called Acrogenous, Endogenous, and Exogenous; while those plants which have no stem, are termed Thallogenous.

Next to the axis we place the leaf, which, as regards venation, presents three distinctive characters; thus, in Acrogenous Plants the leaves or fronds have commonly a forked venation; those of Endogenous Plants are parallel-veined; while those of Exogenous Plants are net-veined or reticulated. Again, stemless plants have no true leaves, but produce a flattened cellular expansion or thallus, which is veinless.

If we now proceed to the organs of reproduction, we find that while some plants have flowers with evident sexes, others have no flowers, and their sexual organs are more or less concealed; hence the former are called Phanerogamous or Phænogamous, the latter Cryptogamous. The stamens and pistil are of the first importance amongst the reproductive organs, because they are essential to the formation of the seed of flowering plants; while the antheridia and archegonia may be considered as possessing about the same importance among flowerless plants. Next in order comes the fruit; thus the presence of a true pericarp is the main characteristic of Angiospermous, and its absence that of Gymnospermous Plants.

Next to the fruit must be placed the floral envelopes, which as regards the number of their parts, are usually ternary in

Monocotyledonous Plants, and quinary or quarternary in Dicotyledons. Lindley remarks, that "the floral envelopes seem to be unconnected with functions of a high order, and to be designed rather for the decoration of plants, or for the purpose of giving variety to the aspect of the vegetable world; and, consequently, their number, form, and condition, presence or absence, regularity or irregularity, are of low and doubtful value, except for specific distinction. There seems, indeed, reason to expect that every natural order will, sooner or later, be found to contain within itself all the variations above alluded to."

The presence or absence of bracts, as well as their appearance and general arrangement; and the characters derived from the different modes of inflorescence, are even of less value than those of the floral envelopes, and must be considered therefore, as occupying the lowest place in our series of the relative value of characters furnished by the organs of plants.

Such are the general principles which must be attended to by those who desire to arrange plants according to their natural affinities, and those systems of classification will be most natural in which the organs of the highest value, and those least liable to change, are especially relied on, in the determination of the affinities of plants. It must be borne in mind, however, that in the best devised natural systems there must be (at least at present) much that is artificial, so that all that we mean by the Natural System is, that it expresses, as far as is possible only, the arrangement of plants according to their natural affinities. (See p. 406.) This imperfection of our natural systems necessarily arises from our incomplete knowledge of existing plants, for as our acquaintance with new kinds is becoming every day extended, our views are liable to be modified or changed, and even supposing plants be ever so naturally arranged, we should be still unable to place them in a linear series, for "Different groups touch each other at several different points, and must be considered as alliances connected with certain great centres. We find also that it is by no means easy to fix the limits of groups. There are constantly aberrant orders, genera, and species, which form links between the groups, and occupy a sort of intermediate territory. In this, as in all departments of natural science, there are no sudden and abrupt changes, but a gradual transition from one series to another. Hence exact and rigid definitions cannot be carried out. In every natural system there must be a certain latitude given to the characters of the groups, and allowances must be made for constant anomalies, in as far as man's definitions are concerned."

Natural Systems.—We now proceed to give an abstract of the more important natural systems. The first attempt at arranging plants according to their natural affinities was by

our celebrated countryman, John Ray, in the year 1682; and imperfect as any scheme must necessarily have been at that day, when the number of plants known was very limited, still his arrangement was in its leading divisions correct, and has formed the foundation of all succeeding systems. He divided plants thus:—

1. Flowerless.
2. Flowering; these being again subdivided into
   a. Dicotyledons.
   b. Monocotyledons.

Ray still further grouped plants together into genera, which were equivalent to our Natural Orders, many of which indicated a true knowledge of natural affinities, and are substantially represented at the present day by such natural orders as the Fungi, Musci, Filices, Coniferæ, Labiatæ, Compositæ, Umbelliferæ, Leguminosæ, &c.

Next in order was the celebrated author of the most perfect artificial system ever devised for the arrangement of plants, namely, Linnæus, who, about the year 1751, drew up a sketch of the natural affinities of plants under the name of Fragments. Many of the divisions thus prepared by Linnæus are identical with natural orders as at present defined, among which we may mention Orchideæ, Gramina, Compositæ nearly, Umbellatæ, Asperifoliæ, Papilionaceæ, Filices, Musci, Fungi, &c. Some of these groups had been previously recognised by Ray and other botanists who had preceded him; while others were then promulgated by himself. No characters, however, were given by Linnæus to the above Fragments. These examples of Linnæan orders will show that while their author was engaged in the formation of his admirable artificial system, he only regarded it as paving the way to the formation of a true natural system, which he himself states to be the *primum et ultimum in botanicis desideratum.*

Jussieu's Natural System.—To Antoine Laurent de Jussieu, however, belongs the great merit of having first devised a comprehensive natural system. His method was first made known in the year 1789. It was founded upon the systems of Ray and Tournefort, to which he made some important additions, more especially, in considering the position of the stamens with respect to the ovary. The following table which requires no explanation, represents his arrangement:—

		Class
Acotyledones		1. Acotyledones.
Monocotyledones	Stamens hypogynous.	2. Monohypogynæ.
	Stamens perigynous.	3. Monoperigynæ.
	Stamens epigynous.	4. Monoepigynæ.

Dicotyledones.	Apetalæ	Stamens epigynous.	5. Epistamineæ.
		Stamens perigynous.	6. Peristamineæ.
		Stamens hypogynous.	7. Hypostamineæ.
	Monopetalæ	Corolla hypogynous.	8. Hypocorollæ.
		Corolla perigynous.	9. Pericorollæ.
		Corolla epigynous.	10. Epicorollæ Synantheræ (anthers coherent).
			11. Epicorollæ Corisantheræ (anthers distinct).
	Polypetalæ	Petals epigynous.	12. Epipetalæ.
		Petals hypogynous.	13. Hypopetalæ.
		Petals perigynous.	14. Peripetalæ.
	Diclines irregulares		15. Diclines.

Under these fifteen classes he arranged 100 natural orders or families, which we shall enumerate at full, because Jussieu's was the first natural arrangement in which an attempt was made to assign characters to natural orders, and because they have formed the basis for all succeeding systematists. Indeed, the limits of a great many of Jussieu's orders are identical with those of the present day.

Class 1.

Order 1. Fungi.
2. Algæ.
3. Hepaticæ.
4. Musci.
5. Filices.
6. Naiades.

Class 2.

7. Aroideæ.
8. Typhæ.
9. Cyperoideæ.
10. Gramineæ.

Class 3.

11. Palmæ.
12. Asparagi.
13. Junci.
14. Lilia.
15 Bromeliæ.
16. Asphodeli.
17. Narcissi.
18 Irides.

Class 4.

19. Musæ.

Order 20. Cannæ.
21. Orchides.
22. Hydrocharides.

Class 5.

23. Aristolochiæ.

Class 6.

24. Elæagni.
25. Thymeleæ.
26. Proteæ.
27. Lauri.
28. Polygoneæ.
29. Atriplices.

Class 7.

30. Amaranthi.
31. Plantagines.
32. Nyctagines.
33. Plumbagines.

Class 8.

34. Lysimachiæ.
35. Pediculares.
36. Acanthi.
37. Jasmineæ.

Order 38. Vitices.
39. Labiatæ.
40. Scrophulariæ.
41. Solaneæ.
42. Boragineæ.
43. Convolvuli.
44. Polemonia.
45. Bignoniæ.
46. Gentianeæ.
47. Apocyneæ.
48. Sapotæ.

CLASS 9.

49. Guaiacanæ.
50. Rhododendra.
51. Ericæ.
52. Campanulaceæ.

CLASS 10.

53. Cichoraceæ.
54. Cynarocephalæ.
55. Corymbiferæ.

CLASS 11.

56. Dipsaceæ.
57. Rubiaceæ.
58. Caprifolia.

CLASS 12.

59. Araliæ.
60. Umbelliferæ.

CLASS 13.

61. Ranunculaceæ.
62. Papaveraceæ.
63. Cruciferæ.
64. Cappardeæ.
65 Sapindi.
66. Acera.
67. Malpighiæ.

Order 68. Hyperica.
69. Guttiferæ.
70. Aurantia.
71. Meliæ.
72. Vites.
73. Gerania.
74. Malvaceæ.
75. Magnoliæ.
76. Anonæ.
77. Menisperma.
78. Berberides.
79. Tiliaceæ.
80. Cisti.
81. Rutaceæ.
82. Caryophylleæ.

CLASS 14.

83. Sempervivæ.
84. Saxifragæ.
85. Cacti.
86. Portulaceæ.
87. Ficoideæ.
88. Onagræ.
89. Myrti.
90. Melastomæ.
91. Salicariæ.
92. Rosaceæ.
93. Leguminosæ.
94. Terebintaceæ.
95. Rhamni.

CLASS 15

96. Euphorbiæ.
97. Cucurbitaceæ.
98. Urticæ.
99. Amentaceæ
100. Coniferæ.

DE CANDOLLE'S NATURAL SYSTEM.—The next system of note, after that of Jussieu, was that of Augustin Pyramus de Candolle, which was first promulgated in 1813. This system, modified however, in some important particulars, is that which is generally in use at the present day, and which, in most of its essential divisions, we shall adopt in this volume. In the first place he divided plants into two great divisions or sub-kingdoms, called Vasculares or Cotyledoneæ, and Cellulares or Acotyledoneæ, the characters of which are as follows:—

Division 1. *Vasculares*, or *Cotyledoneæ*; that is, plants possessing both cellular tissue and vessels; and having an embryo with one or more cotyledons.

Division 2. *Cellulares*, or *Acotyledoneæ*; that is, plants composed of cellular tissue only; and whose embryo is not furnished with cotyledons.

The former division was again divided into two classes, called Exogenæ or Dicotyledoneæ, and Endogenæ or Monocotyledoneæ, the essential characters of which may be thus stated:—

Class 1. *Exogenæ*, or *Dicotyledoneæ*; that is, plants whose vessels are arranged in concentric layers, of which the youngest are the outermost and the softest; and having an embryo with opposite or whorled cotyledons.

Class 2. *Endogenæ*, or *Monocotyledoneæ*; that is, plants whose vessels are arranged in bundles, the youngest being in the middle of the trunk; and having an embryo with solitary or alternate cotyledons.

These classes were again divided into sub-classes or groups. Thus, under the Dicotyledoneæ were placed four groups, named Thalamifloræ, Calycifloræ, Corollifloræ, and Monochlamydeæ. Under Monocotyledoneæ two groups, called Phanerogamæ and Cryptogamæ. The latter group, which included the higher Cryptogamia, was placed under Monocotyledoneæ from a mistaken idea of the plants included in it possessing an embryo, of a somewhat analogous character to the plants in that class of plants. The Acotyledoneæ were also divided into two groups, called Foliosæ and Aphyllæ.

The following is a tabular view of De Candolle's system.

Sub-kingdom 1. VASCULARES, OR COTYLEDONEÆ.

Class 1. *Exogenæ, or Dicotyledoneæ.*

Sub-class 1. *Thalamifloræ.*	Petals distinct, inserted with the stamens on the thalamus.
2. *Calycifloræ.*	Petals distinct, or more or less united, and inserted on the calyx.
3. *Corollifloræ.*	Petals united, and inserted, on the thalamus.
4. *Monochlamydeæ.*	Having only a single circle of floral envelopes, or none.

Class 2. *Endogenæ, or Monocotyledoneæ.*

Sub-class 1. *Phanerogamæ.*	Fructification visible, regular.
2. *Cryptogamæ.*	Fructification hidden, unknown, or irregular.

Sub-kingdom 2. CELLULARES, OR ACOTYLEDONEÆ.

Sub-class 1. *Foliosæ.*	Having leaf-like expansions, and known sexes.
2. *Aphyllæ.*	Having no leaf-like expansions, and no known sexes.

Under these sub-classes he arranged 161 Natural Orders. The enumeration of these is unnecessary in an elementary volume; we shall content ourselves with mentioning a few only, as examples of the different groups. Thus, as examples of *Thalamifloræ,*—Cruciferæ, Caryophylleæ, and Malvaceæ; of *Calycifloræ,*—Rosaceæ, Umbelliferæ, and Compositæ; of *Corollifloræ,*—Convolvulaceæ, Solaneæ, and Labiatæ; of *Monochlamydeæ,*—Polygoneæ, Urticeæ, and Amentaceæ: of *Phanerogamæ,*—Orchideæ, Irideæ, and Gramineæ; of *Cryptogamæ,*—Filices, Equisetaceæ, and Lycopodineæ: of *Foliosæ,*—Musci, and Hepaticæ; and of *Aphyllæ,*—Lichenes, Fungi, and Algæ.

In this system it will be observed that, De Candolle adopted the primary divisions of Jussieu. but he reversed the order of their arrangement; for, instead of commencing with Acotyledons, and passing through Monocotyledons to Dicotyledons, he began with the latter, and proceeded by the Monocotyledons to Acotyledons. The reason for taking this course is thus explained:—

"I place Dicotyledons first because they have the greatest number of distinct and separate organs. Then, as I find families where some of these organs become consolidated, and consequently seem to disappear, I refer them to a lower rank. This principle gives me the series as exhibited in the tabular arrangement above. I have adopted this series partly, because I think it is that which is least removed from a natural sequence, and partly, because it is convenient and easy for study. But let no one imagine that I attach the least importance to it. The true science of general Natural History consists in the study of the symmetry peculiar to each family, and of the relation which these families bear to each other. All the rest is merely a scaffolding, better or worse suited to accomplish that end."

Since the appearance of De Candolle's system numerous other arrangements have been proposed by botanists, as those of Agardh, Perleb, Dumortier, Bartling, Lindley, Schultz, Endlicher, and many others. As all these systems, with the exception of those of Lindley and Endlicher, were never much used, and are not adopted in great systematic works of the present day, it will be unnecessary for us to allude to them any further. A full account of them all may be found in Lindley's valuable work on the Vegetable Kingdom. The systems of Endlicher and Lindley, however, being now used in important systematic works, it will be advisable for us to give a general sketch of their leading characters.

ENDLICHER'S NATURAL SYSTEM.—The system of Endlicher

is adopted in his *Genera Plantarum*, published between the years 1836—1840. The following is a sketch of this system. He divides plants into two great divisions, which he has denominated Regions, and named Thallophyta and Cormophyta. These were again divided into Sections and Cohorts, as follows:—

Region 1. THALLOPHYTA. Plants with no opposition of stem and root; with no vessels and no sexual organs; and with germinating spores lengthening in all directions.

Section 1. *Protophyta.* Plants developed without soil; drawing nourishment from the element in which they grow; and having a vague fructification; as in Algæ and Lichenes.

Section 2. *Hysterophyta.* Plants formed on languid or decaying organisms; nourished from a matrix; all the organs developing at once, and perishing in a definite manner; as in Fungi.

Region 2. CORMOPHYTA. Plants with stem and root in opposite directions; spiral vessels and sexual organs distinct in the more perfect.

Section 3. *Acrobrya.* Stem growing at the point only, the lower part being unchanged, and only used for conveying fluids.

Cohort 1. *Anophyta.* Having no spiral vessels; both sexes perfect; spores free in spore-cases. Examples, Hepaticæ and Musci.

Cohort 2. *Protophyta.* Having vascular bundles more or less perfect; male sex absent; spores free in one or many-celled spore-cases. Examples, Filices and Equisetaceæ.

Cohort 3. *Hysterophyta.* Having perfect sexual organs; seeds without an embryo, polysporous; parasitic. Example, Rhizantheæ.

Section 4. *Amphibrya.* Stem growing at the circumference. Examples, Gramineæ, Liliaceæ, Iridaceæ, Orchidaceæ, and Palmaceæ.

Section 5. *Acramphibrya.* Stem growing at both the apex and circumference.

Cohort 1. *Gymnospermæ.* Ovules naked, receiving impregnation immediately by the micropyle; as in Coniferæ.

Cohort 2. *Apetalæ.* Calyx absent, rudimentary or simple, calycine or coloured, free or united to the ovary. Examples, Cupuliferæ, Urticaceæ, and Polygoneæ.

Cohort 3. *Gamopetalæ.* Both floral envelopes present, the outer calycine, the inner corolline, the latter

being monopetalous; rarely abortive. Examples, Compositæ, Labiatæ, Scrophularineæ, and Ericaceæ.

Cohort 4. *Dialypetalæ.* Both floral envelopes present, the outer being monosepalous or polysepalous, free or united to the ovary, calycine or sometimes corolline; the inner being corolline with distinct petals, or rarely cohering by means of the base of the stamens, and with an epigynous, perigynous, or hypogynous insertion; rarely abortive. Examples, Umbelliferæ, Ranunculaceæ, Cruciferæ, Caryophylleæ, Rosaceæ, and Leguminosæ.

Under these divisions Endlicher included 277 Natural Orders. After Jussieu, he commenced with the simplest plants and gradually proceeded to the more complicated, placing those of the Leguminosæ at the highest point of the series.

LINDLEY'S NATURAL SYSTEM.— To Dr. Lindley especially, belongs the merit of having been the first botanist who made any serious attempts to introduce a natural arrangement of plants into use in this country. The first system proposed by him in 1830 was but a slight modification of that of De Candolle's, and was as follows: —

Class 1.—VASCULARES, OR FLOWERING PLANTS.
- Sub-class 1. *Exogens*, or *Dicotyledons.*
  - Tribe 1. Angiospermæ.
    - § 1. Polypetalous, Apetalous, and Achlamydeous Plants.
    - § 2. Monopetalous Plants.
  - Tribe 2. Gymnospermæ.
- Sub-class 2. *Endogens*, or *Monocotyledons.*
  - Tribe 1. Petaloideæ.
  - Tribe 2. Glumaceæ.

Class 2.—CELLULARES, OR FLOWERLESS PLANTS.
- Tribe 1. Filicoideæ, or Fern-like plants.
- Tribe 2. Muscoideæ, or Moss-like plants.
- Tribe 3. Aphyllæ, or leafless plants.

No attempt was made in this system to form minor groups or divisions of the tribes; but in 1833, in a new system, Lindley arranged the natural orders in groups subordinate to the higher divisions, which were called Nixus (tendencies). The following was the arrangement then proposed: —

		Classes.
Sexuales .	Vasculares . .	1. Exogenæ, Angiospermæ.
		2. Exogenæ, Gymnospermæ.
		3. Endogenæ.
	Evasculares .	4. Rhizantheæ.
5. Esexuales.		

These primary divisions were again divided into Sub-classes, Cohorts, and Nixus or groups of nearly allied Natural Orders. In 1838, Lindley modified his views so far as regarded Exogens, and proposed the following divisions for that class of plants:—

Exogens, or Dicotyledons.

Albumen extremely abundant; embryo minute	1. Albuminosæ.
Albumen absent, or in small quantity.	
Sexes in the same flower.	
Ovary inferior	2. Epigynosæ.
Ovary superior.	
Flowers, if monopetalous, not with a dicarpous ovary . . .	3. Polycarposæ.
Flowers monopetalous, with a dicarpous ovary . . .	4. Dicarposæ.
Sexes in different flowers . . .	5. Diclinosæ.

In the year 1839, Lindley proposed to increase the number of the primary classes of plants to eight, in the following manner:—

State 1. Sexual, or Flowering Plants.

Division 1. Exogens .	Cyclogens.	Class 1. Exogens.
		Class 2. Gymnogens.
		Class 3. Homogens.
Division 2. Endogens	Spermogens.	Class 4. Dictyogens.
		Class 5. Endogens
		Class 6. Sporogens, or Rhizanths.

State 2. Esexual, or Flowerless Plants.

Division 3. Acrogens . . .	Class 7. Cormogens (distinct stem).
	Class 8. Thallogens (no distinct stem).

Lindley finally, in the year 1845, modified his views again, and proposed the following scheme, which is that adopted by him in "The Vegetable Kingdom."

LINDLEY'S NATURAL SYSTEM, 1846.

1. Asexual, or Flowerless Plants.

Stem and leaves undistinguishable .	Class 1. Thallogens.
Stem and leaves distinguishable .	Class 2. Acrogens.

2. SEXUAL, OR FLOWERING PLANTS.

Fructification springing from a thallus	Class 3. Rhizogens.
Fructification springing from a stem.	
Wood of stem youngest in the centre; cotyledon single.	
Leaves parallel-veined, permanent; wood of the stem always confused	Class 4. Endogens.
Leaves net-veined, deciduous; wood of the stem, when perennial, arranged in a circle with a central pith	Class 5. Dictyogens.
Wood of stem youngest at the circumference, always concentric; cotyledons two or more.	
Seeds quite naked . . .	Class 6. Gymnogens.
Seeds enclosed in seed-vessels	Class 7. Exogens.

The Exogens were further divided into four sub-classes thus:—

Sub-class 1. *Diclinous Exogens*, or those with unisexual flowers, and without any customary tendency to form hermaphrodite flowers.

Sub-class 2. *Hypogynous Exogens*, or those with hermaphrodite or polygamous flowers; and stamens entirely free from the calyx and corolla.

Sub-class 3. *Perigynous Exogens*, or those with hermaphrodite or polygamous flowers, and with the stamens growing to the side of either the calyx or corolla; ovary superior, or nearly so

Sub-class 4. *Epigynous Exogens*, or those with hermaphrodite or polygamous flowers, and with the stamens growing to the side of either the calyx or corolla; ovary inferior, or nearly so.

Neither of the other classes are divided into sub-classes, but of Endogens, four sections are distinguished thus:—

1. Flowers glumaceous; (that is to say, composed of bracts not collected in true whorls, but consisting of imbricated colourless or herbaceous scales).
2. Flowers petaloid, or furnished with a true calyx or corolla, or with both, or absolutely naked; unisexual (that is, having sexes altogether in different flowers, without half-formed rudiments of the absent sexes being present).
3. Flowers furnished with a true calyx and corolla, adherent to the ovary; hermaphrodite.
4. Flowers furnished with a true calyx and corolla, free from the ovary; hermaphrodite.

Under the above classes Lindley has included 303 Natural Orders, which he has arranged in groups subordinate to the

sections, sub-classes, and classes, and to which he has given the name of Alliances. These groups are fifty-six in number, and are thus distributed in the different classes:—

Class 1. THALLOGENS

Alliances.	*Examples of Natural Orders.*
1. Algales.	Diatomaceæ.
2. Fungales	Agaricaceæ.
3. Lichenales	Parmeliaceæ.

Class 2 ACROGENS.

4. Muscales	Equisetaceæ, and Bryaceæ.
5. Lycopodales	Lycopodiaceæ.
6. Filicales	Polypodiaceæ.

Class 3. RHIZOGENS.

No alliances	Rafflesiaceæ.

Class 4. ENDOGENS.

Section 1.

7. Glumales	Graminaceæ.

Section 2.

8. Arales	Araceæ.
9. Palmales	Palmaceæ.
10. Hydrales	Naiadaceæ.

Section 3.

11. Narcissales	Iridaceæ.
12. Amomales	Zingiberaceæ.
13 Orchidales	Orchidaceæ.

Section 4.

14. Xyridales	Xyridaceæ.
15. Juncales	Juncaceæ.
16. Liliales	Liliaceæ.
17. Alismales	Alismaceæ.

Class 5. DICTYOGENS.

No alliances	Smilaceæ.

Class 6. GYMNOGENS.

No alliances	Pinaceæ.

Class 7. EXOGENS.

Sub-class 1. *Diclinous Exogens.*

18. Amentales	Salicaceæ.

Alliances.	*Examples of Natural Orders.*
19. Urticales	Urticaceæ.
20. Euphorbiales	Euphorbiaceæ.
21. Quernales	Corylaceæ.
22. Garryales	Garryaceæ.
23. Menispermales	Menispermaceæ.
24. Cucurbitales	Cucurbitaceæ.
25. Papayales	Papayaceæ.
Sub-class 2. *Hypogynous Exogens.*	
26. Violales	Violaceæ.
27. Cistales	Cistaceæ.
28. Malvales	Malvaceæ.
29. Sapindales	Polygalaceæ.
30. Guttiferales	Hypericaceæ.
31. Nymphales	Nymphæaceæ.
32. Ranales	Ranunculaceæ.
33. Berberales	Berberidaceæ.
34. Ericales	Ericaceæ.
35. Rutales	Rutaceæ.
36. Geraniales	Geraniaceæ.
37. Silenales	Caryophyllaceæ.
38. Chenopodales	Chenopodiaceæ.
39. Piperales	Piperaceæ.
Sub-class 3. *Perigynous Exogens.*	
40. Ficoidales	Mesembryaceæ.
41. Daphnales	Thymelaceæ.
42. Rosales	Rosaceæ.
43. Saxifragales	Saxifragaceæ.
44. Rhamnales	Rhamnaceæ.
45. Gentianales	Gentianaceæ.
46. Solanales	Solanaceæ.
47. Cortusales	Primulaceæ.
48. Echiales	Boraginaceæ.
49. Bignonales	Bignoniaceæ.
Sub-class 4. *Epigynous Exogens.*	
50. Campanales	Campanulaceæ.
51. Myrtales	Myrtaceæ.
52. Cactales	Cactaceæ.
53. Grossales	Grossulariaceæ.
54. Cinchonales	Cinchonaceæ.
55. Umbellales	Apiaceæ.
56. Asarales	Aristolochiaceæ.

Having now given a brief description of the more important natural systems which are in use at the present day, we shall conclude our notice of them by the following table of Henslow:—

Henslow's Approximate Comparison of the Systematic Views of Jussieu, De Candolle, Endlicher, and Lindley.

JUSSIEU, 1789.	DE CANDOLLE, 1819.	ENDLICHER, 1836.	LINDLEY, 1846.
	* Cellulares v. Acotyledoneæ.	* Thallophyta.	† Flowerless. (alliances.)
I. ACOTYLEDONES 1 . . . . algæ, 2. lichenes. fungi, 1.	aphyllæ	I. PROTOPHYTA.	I. THALLOGENS . 1. algales. 3. lichenales. 2. fungales.
musci, 4. hepaticæ, 3.	foliosæ ACOTYLEDONES . IV.	II. HYSTEROPHYTA. * * Cormophyta. 1. Anophyta.	II. ACROGENS 4. muscales.
filices, 5.	* * Vasculares v. Cotyledoneæ. † Monocotyledones v. Endogenæ. MONO-CRYPTOGAMÆ . III.	III. ACROBRYA. 2. Protophyta. 3. Hysterophyta.	5. lycopodales. 6. filicales. * * Flowering. III. RHIZOGENS. (1 alliance.)
II. MONOCOTYLEDONES. 2 4 3 mono- -hypogynæ. -epigynæ. -perigynæ.	MONO-PHANEROGAMÆ . II. † † Dicotyledones v. Exogenæ.	IV. AMPHIBRYA.	IV. ENDOGENS (11 alliances.) and V. DICTYOGENS. (1 alliance.)
III. DICOTYLEDONES. 4. Diclines irregulares 15 gymnospermæ. angiospermæ.	4. Monochlamydeæ	1. Gymnospermæ.	VI. GYMNOGENS.
1. Apetalæ 5 6 7 epi- peri- hypo- -stamineæ.		2. Apetalæ.	VII. EXOGENS 1. Diclinous (8 alliances.)
8 9 hypo- peri-	3. Corollifloræ		2. Hypogynous (14 alliances.)
2. Monopetalæ 10 corisantheræ. 11 synantheræ. epi- -corollæ.	2. Calycifloræ DICOTYLEDONES I.	V. ACRAMPHIBRYA 3. Gamopetalæ.	3. Perigynous (10 alliances.)
3. Polypetalæ 12 14 13 epi- peri- hypo- -petalæ.	1. Thalamifloræ	4. Dialypetalæ.	4. Epigynous (7 alliances.)

NATURAL SYSTEM ADOPTED IN THIS MANUAL.—The natural arrangement adopted in this volume, which is founded upon those of Jussieu, De Candolle, and Lindley,—that of De Candolle being the basis, is as follows:—

The Vegetable Kingdom is divided into two sub-kingdoms:—Phanerogamia, Flowering, or Cotyledonous Plants; and Cryptogamia, Flowerless, or Acotyledonous Plants.

1. The *Phanerogamia*, includes plants which have evident flowers; and which are propagated by seeds containing an embryo with one or more cotyledons.

2. The *Cryptogamia*, are those plants which have no flowers; and which are propagated by spores, and are therefore acotyledonous.

The Phanerogamia is divided into two classes, and other subdivisions, thus:—

Class 1. DICOTYLEDONES, in which the embryo is dicotyledonous; the germination exorhizal; the stem exogenous; the leaves with a reticulated venation; and the flowers with a quinary or quaternary arrangement. In this class we have two divisions.

Division 1. *Angiospermia*, in which the ovules are enclosed in an ovary, and are fertilized indirectly by the action of the pollen on the stigma. In this division we have four sub-classes:—

Sub-class 1. *Thalamifloræ*, that is, plants with flowers usually furnished with both a calyx and corolla; the latter composed of distinct petals inserted on the thalamus; stamens hypogynous, or adherent to the sides of the ovary.

Sub-class 2. *Calycifloræ.*—Flowers having usually a calyx and corolla, the latter mostly with distinct petals, and inserted on the calyx; stamens either perigynous, or epigynous. This subclass has two sub-divisions:—

1. *Perigynæ*, in which the calyx is free, or nearly so; the stamens usually perigynous; and the ovary superior.
2. *Epigynæ*, in which the calyx is more or less adherent; and the ovary inferior.

Sub-class 3. *Corollifloræ.*—Flowers having both a calyx and corolla, the latter with united petals; stamens inserted on the corolla or ovary, or free and arising from the thalamus. Of this sub-class we have three sub-divisions:—

1. *Epigynæ*, in which the calyx is adherent; and the ovary consequently inferior.

2. *Hypostamineæ*, in which the stamens are inserted into the thalamus, and do not adhere to the corolla; ovary superior.
3. *Epipetalæ* or *Epicorollæ*, in which the corolla arises from the thalamus, and has the stamens attached to it; ovary superior.

Sub-class 4. *Monochlamydeæ* or *Apetalæ.*—Flowers either having a calyx only, or without both calyx and corolla.

Division 2. *Gymnospermia*, in which the ovules are naked or not enclosed in an ovary, and are fertilized directly by the action of the pollen.

Class 2. MONOCOTYLEDONES, in which the embryo is monocotyledonous; the germination endorhizal; the stem endogenous; the leaves usually with a parallel venation; and the flowers with a ternary arrangement. In this class we have three sub-classes:—

Sub-class 1. *Dictyogenæ.*—Leaves with a reticulated venation, deciduous; rhizome and root with the wood arranged in a concentric manner; floral envelopes verticillate.

Sub-class 2. *Petaloideæ* or *Floridæ.*—Leaves with a parallel venation, permanent; floral envelopes (perianth) verticillate and usually coloured, rarely scaly, sometimes absent. This sub-class has three sub-divisions:—

1. *Epigynæ*, in which the flowers are usually hermaphrodite; the perianth adherent; and the ovary inferior.
2. *Hypogynæ*, in which the flowers are usually hermaphrodite; the perianth free; and the ovary superior.
3. *Diclines*, in which the flowers are usually unisexual; the perianth either absent, or consisting of a few scales.

Sub-class 3. *Glumaceæ.*—Leaves parallel-veined, permanent; flowers glumaceous, that is, having no proper perianth, but consisting of imbricated bracts.

The Cryptogamia constitutes a class by itself, thus:—

Class 3. ACOTYLEDONES, are those plants which are propagated by spores, and are therefore acotyledonous, and have an indefinite or vague germination; the stem is present or absent, in the former case, when woody, it is

acrogenous; the leaves are also either absent or present, in which latter case the veins are forked; they have no true flowers. This has two sub-classes:—

Sub-class 1. *Acrogenæ.*—Plants with the stems and leaves distinguishable; and possessing stomata.

Sub-class 2. *Thallogenæ.*—Plants with no distinction of stems and leaves; stomata absent.

The following is a tabular arrangement of the above system:—

VEGETABLE KINGDOM.

Sub-kingdom 1. Phanerogamia, Cotyledones, or Flowering Plants.

Class 1. DICOTYLEDONES.

Division 1. Angiospermia.

Sub-class 1. Thalamifloræ.
2. Calycifloræ.
   1. Perigynæ.
   2. Epigynæ.
3. Corollifloræ
   1. Epigynæ.
   2. Hypostamineæ.
   3. Epipetalæ.
4. Monochlamydeæ.

Division 2. Gymnospermia.

Class 2. MONOCOTYLEDONES.

Sub-class 1. Dictyogenæ.
2. Petaloideæ or Floridæ.
   1. Epigynæ.
   2. Hypogynæ.
   3. Diclines.
3. Glumaceæ.

Sub-kingdom 2. Cryptogamia, Acotyledones, or Flowerless Plants.

Class 3. ACOTYLEDONES.

Sub-class 1. Acrogenæ.
2. Thallogenæ.

CHAPTER 3.

ARRANGEMENT, CHARACTERS, DISTRIBUTION, PROPERTIES, AND USES OF THE NATURAL ORDERS.

Having now given a general sketch of the various Natural Systems; more especially of that one which we propose to follow in this volume, and described the characters of its essential divisions, we proceed to the description of the various natural orders which we arrange under those divisions. Our attention will be chiefly directed to the more important orders, and especial importance will be given to their diagnostic characters,—or those which are absolutely necessary for their distinction. In this portion of our subject we have made free use of "Lindley's Vegetable Kingdom," to which valuable work we refer those who require fuller details than our object and space will admit of.

In our notice of the more important natural systems, we have seen that, some authors, as Jussieu, Endlicher, and Lindley, commence with the simplest forms of plants, and end with the most complicated; while others, as Ray and De Candolle, take an opposite course, and proceed from the most complicated to the simplest forms. We have adopted the latter plan here, because the more highly developed plants are much better known than the lower, and will be moreover of more general interest to the majority of our readers.

Sub-kingdom I.

PHANEROGAMIA, COTYLEDONES, OR FLOWERING PLANTS.

Class I. DICOTYLEDONES.

Division I. Angiospermia.

Sub-class I. *Thalamifloræ*.

Natural Order 1. Ranunculaceæ, the Crowfoot or Buttercup Order (*figs.* 840—845).—General Character.—*Herbs*, or rarely climbing *shrubs*, with an acrid watery juice. *Leaves* alternate or opposite, generally much divided (*fig.* 348), sometimes entire, with usually dilated and sheathing petioles. *Stipules* sometimes present, but always united to the base of the petiole. *Calyx* of 3—6 (*fig.* 840), usually 5, distinct sepals,

regular or irregular, green or rarely petaloid, deciduous or very rarely persistent; æstivation generally imbricate, some-

Fig 840.

Fig. 841.

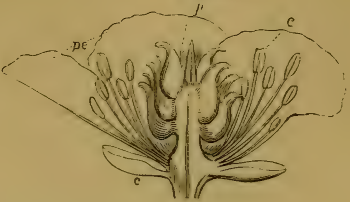


Fig. 842.

Fig. 843.

Fig. 844.

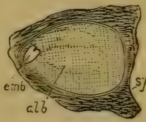


Fig. 845.

Fig. 840. Diagram of the Flower of a species of *Ranunculus.*——*Fig.* 841. Vertical section of the flower of *Ranunculus acris.* *c.* Calyx. *pe.* Petals. *e.* Stamens. *p.* Carpels.——*Fig.* 842. Adnate anther of a Ranunculaceous plant.——*Fig.* 843. Numerous follicles of *Trollius europæus.*——*Fig.* 844. Vertical section of the seed of the Monkshood (*Aconitum*). *sp.* Coverings of the seed. *emb.* Embryo. *alb.* Albumen.——*Fig.* 845. Vertical section of a carpel of *Ranunculus acris.* *o.* Ovary. *g.* Ovule. *s.* Stigma.

times valvate or induplicate. *Corolla* of 3—15 distinct petals, regular or irregular, sometimes absent. *Stamens* numerous (*figs.* 840 and 841), or very rarely few, hypogynous (*fig.* 841, *e*); *anthers* adnate (*fig.* 842), bursting longitudinally. *Carpels* numerous (*fig.* 840), distinct, one-celled (*fig.* 845) or united below so as to form a compound many-celled ovary; *ovary* with one (*fig.* 845, *g*) or many ovules; *ovules* anatropal, attached to the ventral suture (*fig.* 845); *styles* simple. *Fruit* various, either consisting of a number of achænia (*fig.* 841, *p*), or of several follicles (*fig.* 843), or a one or more seeded berry. *Seeds* solitary or numerous, when solitary erect or pendulous; *embryo* minute (*fig.* 844, *emb*), at the base of homogeneous horny albumen.

Diagnosis.—Herbs or rarely shrubs with a watery acrid juice. No stipules separate from the petiole. Sepals, petals, and stamens distinct, hypogynous. Corolla with an imbricated æstivation. Anthers adnate, bursting longitudinally. Carpels always more or less distinct. Seeds without an aril, and with horny albumen, anatropal.

Division of the Order, and Examples of the Genera. — The order is divided into five tribes:—

Tribe 1. *Clematideæ.* Calyx valvate or induplicate. Fruit consisting of a number of achænia. Seed pendulous. *Example:*—Clematis.

Tribe 2. *Anemoneæ.* Calyx imbricated, usually coloured. Fruit consisting of a number of achænia. Seed pendulous. *Examples:*— Anemone, Thalictrum.

Tribe 3. *Ranunculeæ.* Calyx imbricated. Fruit consisting of a number of achænia. Seed erect. *Example :*—Ranunculus.

Tribe 4. *Helleboreæ.* Calyx imbricated. Fruit consisting of one or more whorls of many-seeded follicles. *Examples:*— Helleborus, Aquilegia, Aconitum, Pæonia.

Tribe 5. *Actæeæ* of Lindley. Calyx coloured, imbricated. Fruit succulent, indehiscent, one or many seeded. *Examples:* —Actæa, Podophyllum.

Distribution and Numbers.—The plants of this order occur chiefly in cold damp climates, and are almost unknown in the tropics, except on mountains. Thus Europe contains more than $\frac{1}{5}$th of the order; North America about $\frac{1}{7}$th; South America only $\frac{1}{17}$th; and in Africa there are but very few species, except upon the shores of the Mediterranean. According to Lindley, the order includes 47 genera, and 1000 species.

Properties and Uses.—The plants of this order generally abound in an acrid principle, which in some is even caustic. This acridity is, however, very volatile, so that in most cases it is dissipated by drying, or by infusion in boiling or even cold water ; it varies also in different parts of the same plant, and even in the same parts at different seasons. Some plants contain in addition a narcotic principle. When these principles are in excess they are virulent poisons. Generally the plants of this order are to be regarded with suspicion, although some are simply bitter and tonic. The following are the more important plants of the order, and the uses to which they are applied :—

Clematis erecta and *Flammula.*—The leaves have been used as rubefacients and vesicants. Some other species possess analogous properties.

Hydrastis canadensis.—The root has a very bitter taste, and is used as a tonic in North America, where it is called Yellow-Root.

Ranunculus sceleratus, and *R. Flammula*, are very acrid, which property is also possessed to a certain extent by many other species. *R. Ficaria* has thickened roots which contain a good deal of starch, hence they have been used as food.

Aconitum.—Some species of this genus are very virulent poisons. The

root of *Aconitum ferox*, has been usually considered as the sole source of the celebrated Indian poison, "Bikh or Bish," but Dr. Hooker states that this is also obtained indifferently from *A. Napellus, luridum*, and *palmatum*. *Aconitum Napellus*, a European species, commonly called Monkshood, is the officinal plant of our pharmacopœia. The leaves and root are very poisonous, but when used in proper doses they are narcotic and diaphoretic. Several cases of poisoning have occurred from the root having been mistaken for Horse-radish.* The other European species are almost inert. The properties of the above species are due to a very powerful alkaloid, called *aconitina*. This alkaloid has been much used externally in Neuralgia, and occasionally internally in Acute Rheumatism and Diseases of the Heart. The *Aconitum ferox* contains the largest amount of aconitina of any known species. The root or rhizome of *Aconitum heterophyllum* is said to possess no poisonous properties. According to Thomson it has a great reputation in India as a febrifuge and antiperiodic medicine.

Helleborus officinalis.—The rhizome and roots of this species constituted the Black Hellebore of the ancients, which was much used by them as a drastic purgative. *Helleborus niger* is still occasionally employed in this country, and possesses similar properties. *Helleborus viridis* and *H. fœtidus* are also of a like nature, and may be used as efficient substitutes.

Delphinium Staphysagria.—The seeds of this plant are sometimes employed; they are commonly known under the name of Staves-acre seeds. They contain an alkaloid, called Delphinia. They have been chiefly used for destroying vermin. Delphinia has also been used externally in Neuralgia and Rheumatism.

Coptis trifoliata, Gold Thread.—The root of this plant, which is a native of North America, is a pure and powerful bitter, and is used as a stomachic and tonic. The root of *Coptis Teeta*, is found in the bazaars of India. It is known under the names of Mishmee-Bitter or Mahmira. It is intensely and powerfully bitter, and is a valuable tonic.

Nigella sativa.—The seeds were formerly employed instead of pepper. It is supposed that these seeds, or those of another species used by the Affghans for flavouring curries, is the Black Cummin of Scripture (Isaiah xxviii. 25, 27).

Xanthorrhiza apiifolia.—The wood and bark, as well as a gum and resin which may be obtained from them, have a pure bitter taste, and tonic properties.

Podophyllum peltatum, May-apple. — The fruit is acid, hence its name Wild Lemon; it is sometimes eaten. The leaves possess poisonous properties, but when used in proper doses, they act as a cathartic, and are thus sometimes employed in North America.

Many plants of the order are commonly cultivated in our gardens; as various species of *Clematis, Anemone, Ranunculus, Eranthis* (Winter Aconite), *Helleborus* (Christmas Rose), *Aquilegia* (Columbines), *Delphinium* (Larkspurs), *Aconitum* (Monkshoods), *Pæonia* (Pæonies), &c. The *Moutan officinalis* is the Tree Pæony of China, which is remarkable for its very large showy flowers, and for the number of its blossoms; thus, Fortune mentions a plant in the neighbourhood of Shanghae which yearly produced from 300 to 400 flowers.

Natural Order 2. DILLENIACEÆ. — The Dillenia Order. — General Character —*Trees, shrubs*, or rarely *herbs*. *Leaves* usually alternate, very rarely opposite, generally *exstipulate*. *Sepals* 5, persistent, in two rows. *Petals* 5, deciduous, hypogynous, imbricated. *Stamens* numerous, hypogynous. *Carpels* 2—5, rarely 1, more or less distinct. *Fruit* formed of from 2—5 distinct or adherent carpels, rarely 1. *Seeds* numerous, or 2 or 1 by abortion, anatropal, arillate; *albumen* homogeneous, fleshy; *embryo* minute.

Diagnosis. — Stipules absent, except in rare cases. Sepals and petals 5 each, hypogynous, the former persistent in two

* See paper by the Author, in the *Pharmaceutical Journal*, vol. 15, p. 449.

rows, the latter with an imbricated æstivation. Carpels more or less distinct. Seeds arillate; albumen fleshy, homogeneous.

Distribution, Examples of the Genera, and Numbers. — The plants of this order occur chiefly in Australia, India, and equinoctial America; a few species have been also found in equinoctial Africa; none occur in Europe. *Examples:*— Dillenia, Hibbertia, Candollea, Hemistemma, Delima, Tetracera. There are above 26 genera, and 200 species of plants known belonging to this order.

Properties and Uses.—The plants of the order have usually astringent properties, and have been used as vulneraries, and for tanning in Brazil. The young calyces of some species of *Dillenia* have an acid taste, and are employed as an ingredient of curries in some parts of India. Some species of *Dillenia* grow to a large size and form hard durable timber. There are no plants belonging to the order which are applied to any use in this country.

Most of the Indian species belonging to the genus *Dillenia*, are remarkable not only for their evergreen foliage, but also for the beauty of their flowers. They are sometimes cultivated as stove or greenhouse plants in this country.

Natural Order 3. MAGNOLIACEÆ.—The Magnolia Order.— General Character.—*Trees* or *shrubs*, with alternate leathery *leaves* (*fig.* 313, *b*), and with usually large convolute *stipules*, which enclose the leaf-bud and fall off as it expands. *Sepals* usually three to six, deciduous. *Petals* three or more, hypogynous, in two or more rows. *Stamens* numerous, hypogynous (*fig.* 589, *e*). *Carpels* several, one-celled, often arranged upon an elongated thalamus (*fig.* 589, *c*). *Fruit* consisting of numerous, dry or succulent, dehiscent (*fig.* 652), or indehiscent carpels, distinct or somewhat coherent. *Seeds* anatropal, with or without an aril, solitary or several, often suspended from the fruit by a long funiculus (*fig.* 652). *Embryo* minute; *albumen* fleshy, homogeneous.

Diagnosis.—Trees or shrubs; leaves alternate.—Stipules usually present, and then large and sheathing the leaf-bud, deciduous. Sepals and petals with a ternary arrangement of their parts, hypogynous, the former deciduous, the latter with an imbricated æstivation. Carpels distinct. Albumen homogeneous.

Division of the Order, and Examples of the Genera.—The order is divided into two tribes:—

Tribe 1. *Magnolieæ.*—Carpels arranged upon an elongated thalamus in a cone-like manner. Leaves not dotted, or scarcely so. *Examples:*—Magnolia, Liriodendron.

Tribe 2. *Wintereæ.*—Carpels forming but one whorl. Leaves dotted, and often exstipulate. *Examples:*—Drimys, Illicium, Tasmannia.

Distribution and Numbers.—The majority of the order are found in North America. Some also occur in the West Indies,

Japan, China, India, South America, Australia, and New Zealand. None have been found in Africa or any of the adjoining islands, or in Europe. There are 12 genera, and 168 species.

Properties and Uses.—The plants of the order are chiefly remarkable for bitter, tonic, aromatic properties. The following are the more important:—

Magnolia glauca, Swamp Sassafras or Beaver Tree.—The bark is tonic and aromatic, resembling Cinchona in its action. The unripe fruits of other species, as *Magnolia Frazeri* and *M. acuminata*, have similar properties.

Liriodendron tulipifera, Tulip-tree.—The bark possesses bitter and tonic properties, and is used in similar cases to the preceding.

Tasmannia aromatica.—The fruit is used in New Holland as a substitute for pepper.

Drimys Winteri or *aromatica.*—The bark, which is commonly known under the name of Winter's Bark, has tonic, aromatic, and stimulant properties. It is often confounded with Canella Bark, which has been termed Spurious Winter's Bark. It was formerly much employed in this country, but at present, it is seldom used. *Drimys granatensis*, possesses similar properties.

Illicium anisatum, Star-anise.—The whole plant, particularly the fruit, has the flavour and odour of Aniseed It is used by the Chinese as an aromatic and carminative, and as a spice. The oil obtained from the seeds is said to be sometimes substituted for oil of Anise.

The plants of this order are also remarkable for the fragrance and beauty of their flowers and foliage; hence they are favourite objects of culture in this country, either as hardy plants, such as several Magnolias, and the Tulip-tree; or as stove or greenhouse plants.

Natural Order 4. ANONACEÆ.—The Custard-Apple Order.—General Character.—*Trees* or *shrubs*. *Leaves* alternate, simple, exstipulate. *Calyx* of three sepals, generally coherent at the base, persistent. *Corolla* of six petals, in two whorls, leathery; *æstivation* usually valvate, hypogynous, rarely united, or more rarely altogether absent. *Stamens* usually numerous, and inserted on a large hypogynous thalamus; *connective* enlarged, 4-angled; *anthers* adnate. *Carpels* usually numerous, distinct or united, with one or more anatropal *ovules*. *Fruit* composed of a number of dry or succulent carpels, which are distinct, or united so as to form a fleshy mass. *Seeds* one or more, anatropal; *embryo* minute; *albumen* ruminate.

Diagnosis.—Trees or shrubs. Leaves alternate. No stipules. Calyx of 3 sepals, deciduous. Petals 6, in two rows, hypogynous, usually valvate. Anthers with an enlarged 4-cornered connective. Albumen ruminate.

Distribution, Examples of the Genera, and Numbers.—The plants of this order are almost entirely confined to the tropical regions of Asia, Africa, and America. None are found in Europe. *Examples*:—Xylopia, Uvaria, Duguetia, Anona, Monodora. There are about 20 known genera, containing 300 species.

Properties and Uses.—Generally aromatic and fragrant in all their parts. Some are useful, as—

Xylopia aromatica (*Habzelia Æthiopica*), De C., commonly known as Piper Æthiopicum. The dry fruit of this plant is used by the African negroes on

account of its stimulant and carminative effects, and also as a condiment. *Xylopia undulata* has nearly similar properties. *Xylopia glabra* yields the Bitter wood of the West Indies, which has tonic properties.

Uvaria febrifuga.—The fruit of this species is supposed to be the one which is used as a febrifuge by the Indians on the Orinoco; according to Martius however, that is obtained from the *Xylopia grandiflora.*

Cœlocline (*Unona*) *polycarpa*, D. C.—The Berberine or Yellow-dye tree of Soudan. — The bark of this tree yields a beautiful yellow colour, which is much used as a dyeing material in certain parts of Africa. When reduced to a coarse powder, it is also a topical remedy of great repute, in the treatment of indolent ulcers, and chronic leprous sores of the extremities. It contains *Berberine*, to which its medicinal virtues are probably due.

Duguetia quitarensis.—According to Schomburgh, the strong elastic wood called Lance-wood, chiefly used by coachmakers, is furnished by this plant, which is a native of Guiana.

Anona squamosa and *muricata*, yield the delicious succulent fruits of the East and West Indies, called Custard Apples; that of *A. squamosa* is called Sweet-sop; that of *A. muricata*, Sour-sop. Other species are also esteemed for their fruits, as *Anona reticulata*, which yields the netted Custard-apple, and *A. Cherimolia*, which produces the Cherimoyer of Peru. Another species, namely *A. palustris*, is the source of West Indian Cork-wood, so called from its elasticity and lightness.

Monodora Myristica, the Calabash Nutmeg, has similar aromatic qualities to the true Nutmeg of commerce.

Natural Order 5. Lardizabalaceæ.—The Lardizabala Order. —General Character.—*Shrubs* of a twining habit. *Leaves* alternate, exstipulate, compound. *Flowers* unisexual. *Barren flower*:—*Calyx* and *corolla* with a ternary arrangement of their parts, each in one or two whorls, deciduous. *Stamens* 6, opposite the petals, usually monadelphous, sometimes distinct. *Rudimentary ovaries* 2 or 3. *Fertile flower*:—*Calyx* and *corolla* as before, but larger, hypogynous. *Stamens* 6, very imperfect and sterile. *Carpels* distinct, generally 3, rarely 6 or 9, 1-celled; *ovules* usually numerous, rarely 1, imbedded on the inner surface of the ovary. *Fruit* baccate, or sometimes follicular. *Seed* with usually a minute embryo in a large quantity of solid albumen.

Diagnosis.—Twining shrubs. Leaves alternate, exstipulate, compound. Unisexual flowers. Carpels distinct, superior. Seeds parietal, imbedded; embryo usually minute with abundant homogeneous albumen.

Distribution, &c.—There are but 7 genera, and 15 species, belonging to this order; of which, according to Lindley, two genera inhabit the cooler parts of South America, one is a tropical form, and the remainder are from the temperate parts of China. *Examples*:—Burasaia, Holbœllia, Stauntonia, Lardizabala.

Properties and Uses.—The plants of this order appear to be without any active properties. Some have edible fruits. Others have been introduced into our greenhouses as evergreen climbers.

Natural Order 6. Schizandraceæ.—The Schizandra Order. —General Character.—Trailing *shrubs*. *Leaves* alternate, exstipulate, simple, often dotted. *Flowers* unisexual. *Calyx* and *corolla* with a ternary arrangement of their parts, hypogynous, imbricated. *Barren flower*:—*Stamens* numerous, monadelphous

or distinct, hypogynous; *anthers* 2-celled, extrorse, with a thickened connective. *Fertile flower:*—*Carpels* numerous, 1-celled, distinct or coherent; *ovules* 2, pendulous. *Fruits* numerous, collected into a cluster, baccate. *Seeds* with abundant solid fleshy albumen; *embryo* very minute.

Diagnosis.—Scrambling shrubs. Leaves alternate, exstipulate, simple. Flowers unisexual. Sepals and petals imbricated. Stamens numerous, hypogynous. Ovules pendulous; embryo very minute, with abundant homogeneous albumen.

Distribution, &c.—This small order only contains 5 genera, and 12 species. They occur in India, Japan, and the southern parts of North America. *Examples:*—Kadsura, Schizandra, Hortonia.

Properties and Uses.—The plants of this order are insipid and mucilaginous. Some have edible fruits. A species of *Schizandra* and *Sphærostema* are cultivated in our greenhouses and stoves.

Natural Order 7. MENISPERMACEÆ.—The Moon-Seed Order.—General Character.—Climbing or trailing *shrubs*. *Leaves* alternate, simple, exstipulate, usually entire. *Flowers* generally diœcious, but sometimes imperfectly unisexual, rarely perfect or polygamous. *Barren flower:*—*Calyx* and *corolla* with a ternary arrangement of their parts, generally in two whorls, imbricate or valvate. *Stamens* usually distinct, sometimes monadelphous. *Ovaria* rudimentary or wanting. *Fertile flower:*—*Sepals* and *petals* usually resembling those of the barren flower. *Stamens* imperfectly developed, or wanting. *Carpels* usually 3, sometimes 6, commonly supported on a gynophore, distinct, 1-celled, each containing one curved ovule. *Fruits* drupaceous, curved around a central placental process, 1-celled. *Seeds* 1 in each cell, and curved so as to assume the form of that cell; *embryo* curved; *albumen* present or absent; when present homogeneous, or partially divided into plates or convolutions by the projection inwards of the membranous covering of the seed.

Diagnosis.—Trailing or climbing shrubs. Leaves alternate, simple, exstipulate. Flowers usually diœcious. Sepals, petals, stamens, and carpels, with a ternary arrangement, hypogynous. Carpels placed on a gynophore, distinct. Fruits 1-celled, curved. Seed solitary, curved; embryo curved; albumen absent, or usually small in amount, and then either homogeneous or divided.

Miers remarks, "that there is probably no family so completely heteromorphous as the Menispermaceæ, or presents such extreme and aberrant features at variance with its normal structure." Hence there is great difficulty in drawing up a satisfactory diagnosis of this order.

Distribution, &c.—The plants of this order are chiefly found in the forests of the tropical parts of Asia and America. None

occur in Europe. *Examples:*—Coscinium, Anamirta, Jateorhiza, Menispermum, Cissampelos, Cocculus. There are 44 genera, and 302 species.

Properties and Uses.—The plants of this order are chiefly remarkable for their narcotic and bitter properties. A few are mucilaginous. When the narcotic principle is in excess they are very poisonous. Some are valuable tonics. The more important useful plants are as follows:—

Coscinium fenestratum.— According to Ainslie, the wood and bark possess stomachic properties. The wood has been imported into this country from Ceylon, and sold as true Calumba-root; it contains much Berberine.

Anamirta paniculata (*Cocculus indicus*).—The fruit of this plant is poisonous. It has been extensively employed for a long period as a poison for taking fish and game, which it stupifies. It is also used to a great extent, (chiefly by publicans,) to impart a bitter taste to malt liquor, and to increase its intoxicating effects. It has been also employed externally to destroy vermin, and for the cure of some skin diseases. It owes its active properties to a very poisonous crystalline alkaloid contained in the seed, called Picrotoxine. The pericarp also contains two other alkaloids in minute quantity, which have been named Menispermine and Paramenispermine, of which but little is known.

Jateorhiza palmata (*Cocculus palmatus*).—The root of this plant furnishes the Calumba of the Materia Medica, which is extensively used as a tonic. It would appear also to possess to a certain extent narcotic properties. Its active properties are due to a crystalline alkaloid called Calumbine.

Cissampelos Pareira.—The root is an article of the Materia Medica, and is commonly known under the name of Pareira brava. It possesses bitter tonic, and diuretic properties. It would appear probable, however, that *Cissampelos glaberrima*, and perhaps other allied species, and even other plants of the same order, may also furnish a portion of the Pareira brava of commerce. The stem possesses similar but less powerful properties; it is however frequently mixed with the root. Pareira brava contains an uncrystallizable alkaloid named Cissampeline or Pelosine.

Natural Order 8. BERBERIDACEÆ.—The Barberry Order (*figs.* 846—849).—General Character—*Shrubs* or *herbaceous* perennial plants. Leaves alternate (*fig.* 360), compound, usually exstipulate. The leaves are frequently apparently simple, but in such cases it will be found that, the blade is articulated to the petiole, which is evidence of their compound nature. (See p. 156.) The stem is generally free from hairs and other appendages of a similar character, but it is often spiny (*fig.* 360). These spines are nothing more than the hardened veins of some of the leaves, between which the parenchyma is not developed. *Sepals*, 3, 4, or 6, deciduous, in two whorls (*fig.* 767). *Petals* equal to the sepals in number and opposite to them, or twice as many, hypogynous (*fig.* 767). *Stamens* hypogynous (*fig.* 848), equal to the petals in number, and opposite to them; *anthers* 2-celled, each opening by a valve from the bottom to the top (*figs.* 848 and 528). *Carpel* solitary, free, 1-celled (*fig.* 848); *style* somewhat lateral; *stigma* orbicular (*fig.* 848); *ovules* anatropal, attached to a sutural *placenta* (*figs.* 847 and 848). *Fruit* baccate, or dry and capsular. *Seeds* (*fig.* 849) usually with a minute *embryo; albumen* between fleshy and hairy.

Diagnosis.—Leaves alternate, compound, very often spiny.

Fig. 846. Fig. 847.

Fig. 848. Fig. 849.

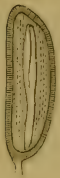


Fig. 846. Diagram of the flower of *Epimedium.*——*Fig.* 847. Vertical section of the flower of *Epimedium.* ——*Fig.* 848. Vertical section of the ovary of *Berberis.*——*Fig.* 849. Vertical section of the seed of *Berberis*, with the embryo in the axis surrounded by albumen.

Flowers regular and symmetrical. Sepals 3, 4, or 6, deciduous. Petals hypogynous, and opposite to the sepals. Stamens definite, hypogynous, opposite to the petals; anthers 2-celled, each opening by a recurved valve. Carpel solitary; placenta sutural; ovules anatropal. Seeds with albumen.

Distribution, &c.—They are found in the temperate parts of Europe, America, and Asia. They are very common in the mountainous parts of the north of India. *Examples:*—Berberis, Epimedium, Leontice. There are 12 genera, and 100 species.

Properties and Uses.—The plants of the order are acid, astringent, and bitter. Their acid properties are due to the presence of oxalic acid. The only plant of particular interest is the

Berberis vulgaris, The common Barberry.—The fruits of this and other species are acid and astringent, and form a refreshing preserve. Its bark and stem are very astringent, and are sometimes used by dyers in the preparation of a yellow dye. This plant, as well as other species, some of which from their distinctly pinnate leaves, have been supposed improperly to constitute a new genus, called *Mahonia*, are shrubs which are frequently cultivated in our gardens. The Lycium of Dioscorides has been ascertained by Dr. Royle to have been obtained from one or more species of *Berberis*. The Barberry contains a yellow crystalline matter, named Berberine.

Natural Order 9. CABOMBACEÆ.—The Water-Shield Order.—General Character.—*Aquatic plants,* with floating peltate

leaves. *Sepals* and *petals* 3 or 4, alternating with each other. *Stamens* definite or numerous. *Thalamus* flattened, small. *Carpels* 2 or more, distinct. *Fruit* indehiscent. *Seeds* few; *embryo* minute, enclosed in a vitellus, and outside of abundant fleshy albumen.

Diagnosis.—The only orders likely to be confounded with this, are the Nymphæaceæ, and Nelumbiaceæ. The plants belonging to the Cabombaceæ are distinguished from the Nymphæaceæ, by having *distinct carpels, sutural placenta, few seeds, no evident thalamus,* and by the *presence of fleshy instead of farinaceous albumen;* and from the Nelumbiaceæ, by their *small thalamus,* by having *more than one seed in each carpel,* by their *minute embryo,* and *abundant albumen.*

Distribution, &c. — There are only 2 genera, and 3 species belonging to this order. They occur in America, Australia, and India. *Examples:* — Cabomba, Hydropeltis.

Properties.—They have no important properties. *Hydropeltis purpurea* is said to be nutritious.

Natural Order 10. Nymphæaceæ. —The Water-Lily Order (*figs.* 850—852). — General Character. — *Aquatic herbs.*

Fig. 850.

Fig. 851.

Fig. 852.

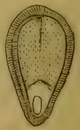


Fig. 850 Flower of Yellow Water-Lily (*Nuphar lutea*).——*Fig.* 851. Ovary of *Nuphar* with numerous radiating stigmas.——*Fig.* 852. Vertical section of the seed of *Nymphæa alba*, showing the embryo enclosed in a vitellus, and on the outside of albumen.

Leaves floating, peltate or cordate. *Flowers* solitary, large and showy. *Sepals* usually 4 (*fig.* 438, *c, c, c, c*), persistent, generally petaloid on their inside. *Petals* numerous (*fig.* 438, *p*), deciduous, often passing by gradual transition into the stamens (*fig.* 438, *p*, 1, 2), in the same way as the sepals pass into the petals; inserted on a fleshy thalamus below the stamens (*fig* 509). *Stamens* numerous, placed upon the thalamus; *filaments* petaloid (*figs.* 438, *c*, 1, 2, 3, 4, 5, and 850). *Thalamus* large, and forming a disk-like expansion, more or less surrounding the ovary, and

having inserted upon it the petals and stamens (*fig.* 850). *Carpels* numerous, united so as to form a compound pistil (*fig.* 851); *ovary* many-celled (*fig.* 768); *styles* absent; *stigmas* radiating on the top (*fig.* 851), and alternate with the dissepiments. *Fruit* indehiscent, many-celled. *Seeds* numerous, attached all over the spongy dissepiments; *embryo* minute, enclosed in a vitellus, and on the outside of farinaceous albumen (*fig.* 852).

Diagnosis.— Aquatic herbs with floating leaves. Thalamus large, and forming a disk-like expansion more or less surrounding the ovary. Carpels united so as to form a compound many-celled pistil; stigmas radiating on the top, and alternate with the dissepiments; ovules numerous, attached all over the dissepiments. Embryo minute, on the outside of farinaceous albumen, enclosed in a vitellus.

Distribution, &c.— The plants of this order are chiefly found in quiet waters, throughout the whole of the northern hemisphere; they are, generally speaking, rare in the southern hemisphere. *Examples:*— Euryale, Victoria, Nymphæa, Nuphar, Barclaya. There are 5 genera, and 50 species.

Properties and Uses.—The plants of this order have bitter and astringent properties. They have been also generally considered to be sedative and narcotic; but there does not appear to be any foundation for such an opinion. Many contain a large quantity of starch both in their rhizomes and seeds, hence, such parts constitute a favourite food in some countries. The plants are chiefly remarkable for their large showy flowers, and for the gradual transition which their parts exhibit from the sepals to the petals and stamens. The most remarkable plant of the order is the

Victoria regia.—This is a native of Equatorial America, and has been introduced recently into this country, where it has excited much interest, both from the beauty and size of its flowers, and from its enormous singularly constructed leaves. The flowers when fully expanded are more than a foot in diameter; and the leaves, which are turned up at their edges, vary from four to eight feet in diameter. The plant is commonly known in this country as the Victoria Water-lily, and in South America under the name of Water-maize, as the seeds are there used for food, for which purpose they are commonly roasted with Maize or Indian Corn.

Natural Order 11. Nelumbiaceæ.—The Water-Bean Order. —General Character.—*Aquatic herbs. Leaves* peltate, rising above the water. *Flowers* large and showy. *Sepals* 4 or 5. *Petals* numerous, in several whorls. *Stamens* numerous, in several whorls; *filaments* petaloid. *Thalamus* very large, flattened at the top, and excavated so as to present a number of hollows, each of which contains a single *carpel* (*fig.* 640). *Fruit* consisting of the ripened nut-like carpels, which are half buried in the cavities of the thalamus. *Seeds* solitary, or rarely 2; without *albumen; embryo* large, enclosed in a membrane, with two fleshy cotyledons, and a much developed plumule.

Diagnosis.— Aquatic herbs with peltate leaves. Thalamus

very large, flattened at the top, and excavated so as to present a number of hollows. Carpels distinct, and partially imbedded in the large honey-combed thalamus. Fruit of numerous 1 or 2-seeded, nut-like bodies. Albumen none; plumule very large.

Distribution, &c.—These beautiful water plants are natives of stagnant or quiet waters of temperate and tropical regions in the northern hemisphere; most abundant in the East Indies. There is but 1 genus *Nelumbium*, which includes 3 species.

Properties and Uses.—Chiefly remarkable for their large beautiful flowers and leaves. The nut-like fruits of all the species are edible, as well as their rhizomes, which contain starch like those of the Nymphæas. The most interesting plant is the

Nelumbium speciosum.—The fruit of this plant is commonly considered to have been the Egyptian Bean of Pythagoras; and the flower the Lotus so often represented on the monuments of Egypt and India. The plant however is no longer found in Egypt, but it is common in India. The leaf and flower-stalks contain a large number of spiral vessels, which, when extracted, are used for wicks, "which on great and solemn occasions are burnt in the lamps of the Hindoos placed before the shrines of their gods."

Natural Order 12. SARRACENIACEÆ.—The Sarracenia, Water-Pitcher, or Side-Saddle Flower Order.—General Character.—*Perennial herbs*, growing in boggy places, with radical hollow leaves, which are pitcher or trumpet-shaped (*figs.* 368 and 369). *Sepals* 4—6, usually 5, persistent, imbricated. *Petals* 5, hypogynous, sometimes absent. *Stamens* numerous, hypogynous; *anthers* adnate, 2-celled. *Carpels* 3—5, united so as to form a compound 3—5-celled ovary; *ovules* numerous; *placentas* axile; *style* simple and truncate, or expanded at its top into a large shield-like angular process, with one stigma beneath each of its angles. *Capsule* 3—5-celled, dehiscing loculicidally. *Seeds* numerous, attached to large axile placentas; *albumen* abundant.

Diagnosis.—Perennial boggy plants, with pitcher or trumpet-shaped leaves. Calyx permanent, imbricated. Carpels united so as to form a compound ovary, and a 3—5-celled dehiscing fruit, with large axile placentas; albumen abundant.

Distribution, &c.—There are 3 genera, and 8 species, of which 6 are confined to the bogs of North America, 1, *Heliamphora nutans*, occurs in Guiana, and 1 is found in California. *Examples:*—Sarracenia, Heliamphora, Darlingtonia.

Properties and Uses.—Unknown. The pitchers are lined by hairy or glandular appendages, which appear to secrete the peculiar fluid always found in them; but this is by no means ascertained. The use of this secretion is also unknown.

Natural Order 13. PAPAVERACEÆ.—The Poppy Order (*figs.* 853—855).—General Character.—*Herbs* or *shrubs*, usually with a milky juice (white or coloured). *Leaves* alternate, exstipulate. *Sepals* usually 2 (*fig.* 853), or rarely 3, deciduous (*fig.* 457). *Petals* 4 (*figs.* 853 and 854), or rarely 6, or some

Fig. 853.

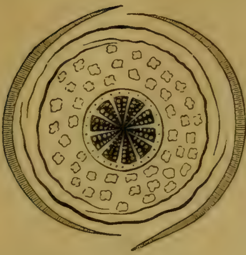


Fig. 854.

Fig. 855.

Fig. 853. Diagram of the flower of the Poppy, with two sepals, four crumpled petals, numerous stamens, and a compound pistil with several parietal placentas.——*Fig.* 854. Flower of Celandine (*Chelidonium majus*). *sti.* 2 stigmas on the apex of a lengthened or pod-like ovary. ——*Fig.* 855. Siliquæ-form or pod-shaped capsule of Celandine.

multiple of 4, or very rarely wanting, usually crumpled in æstivation (*fig.* 853), hypogynous. *Stamens* generally numerous, hypogynous (*figs.* 853 and 854); *anthers* 2-celled, innate (*fig.* 428). *Ovary* 1-celled, with 2 (*fig.* 855) or more (*fig.* 853) parietal placentas, which project more or less from the walls into its cavity, and in *Romneya* actually adhere in the axis; *styles* absent (*fig.* 428), or very short; *stigmas* 2 (*fig.* 854, *sti*), (or many (*fig.* 428, *sti*), opposite to the placenta, processes; when numerous, they form a star-like process on the top of the ovary (*fig.* 428); *ovules* numerous. *Fruit* 1-celled, and either pod-shaped, with 2 parietal placentas (*fig.* 855), or capsular, with several placentas (*fig.* 428); dehiscing by valves or pores, or sometimes indehiscent. *Seeds* usually numerous; *embryo* in fleshy-oily albumen (*fig.* 753).

Diagnosis. — Usually herbs with a milky juice. Leaves alternate and exstipulate. Peduncles 1-flowered; flowers regular and symmetrical. Calyx and corolla with a binary or ternary arrangement of their parts, deciduous, hypogynous. Stamens numerous, hypogynous. Ovary compound, 1-celled, with parietal placentas, stigmas opposite to the placentas. Fruit 1-celled. Seeds numerous, albuminous.

Distribution, &c. — Nearly two-thirds of the plants of this order are natives of Europe, and are mostly annuals. They are almost unknown in tropical regions, and are but sparingly distributed out of Europe in a wild condition. *Examples:* — Sanguinaria, Argemone, Chelidonium, Papaver, Glaucium, Eschscholtzia. There are 18 genera, and 130 species.

Properties and Uses. — The plants of this order are in almost

all cases characterised by well-marked narcotic properties. Some are acrid, while others are purgative. In a medical point of view, this order must be regarded as the most important in the Vegetable Kingdom, from its yielding Opium, undoubtedly the most valuable drug of the Materia Medica. The more important plants are the following: —

Sanguinaria canadensis, or Puccoon.—The root of this plant, which is a native of North America, contains a red juice, from which circumstance it is termed Blood-root. It is used internally in large doses, as an emetic and purgative, and in smaller quantities, it is reputed stimulant, diaphoretic, and expectorant. When applied externally, it has been stated to have well-marked escharotic properties, and has been used, combined with chloride of zinc, as an external application for the destruction of cancerous growths. From recent trials in this country, however, it would appear, that it possesses to no evident extent any such qualities.

Chelidonium majus, Celandine. — This plant is a native of this country, growing in the neighbourhood of villages. It has an orange-coloured juice of a poisonous nature, which is a popular external application for the cure of warts, and has been used successfully in opacities of the cornea. It has been also administered internally, and is reputed aperient, diuretic, and stimulant.

Argemone mexicana, Mexican or Gamboge Thistle. — The seeds possess narcotico acrid properties. An oil may be obtained from them by expression, which possesses aperient and other qualities, and has been recommended as a cure for Cholera. In the West Indies, the seeds are also used as a substitute for Ipecacuanha.

Papaver somniferum, Opium Poppy. — The valuable drug Opium is obtained by making incisions into the unripe capsules of this plant, and inspissating the juice which under such circumstances exudes from them. It has been known from early times, having been alluded to by Hippocrates, Diagoras, and Dioscorides. Various kinds of opium have been described under the names of Turkey or Smyrna, Constantinople, Egyptian, Persian, European, and Indian. Smyrna opium which is produced in Asia Minor is that commonly used in this country. Its consumption is largely on the increase; thus, in 1839, the quantity imported into Great Britain was 41,000, and in 1852, 114,000 pounds, and it is even much greater at the present time. In India the quantity of opium produced annually is probably not much less than 8,000,000 pounds, yielding a revenue of about 4½ millions sterling to the East Indian Government. Of this enormous quantity, at least five millions of pounds are exported to and consumed in China, representing a market value of about as many pounds sterling. Opium possesses in a marked degree the narcotic properties of the plants of the order from which it is obtained. In large doses it is a narcotic poison. It is also regarded as anodyne, stimulant, and diaphoretic, according to circumstances. Its properties are chiefly due to a peculiar alkaloid called Morphia, which is combined with meconic acid. Its properties are also due, to some extent at least, to other peculiar principles which it contains, as Codeia, Narcotine, Narceine, Meconine, and Meconic acid, as well as some others occasionally found, and of which but little is known. While the juice of the pericarp has been thus stated to possess such active properties, the seeds of the Opium Poppy are bland and wholesome. They yield by expression an oil which is much used on the Continent, and also in this country, as a substitute for olive oil, and for other purposes. It is one of the oils employed for adulterating olive oil. The cake left after the oil has been extracted may be used for fattening cattle.

Papaver Rhœas, the Common Red or Corn Poppy, has scarlet or red petals, as its name implies. A syrup prepared from these petals is used as a colouring ingredient by the medical practitioner. The fresh petals are also supposed to possess slight narcotic properties.

Many genera belonging to this order are commonly cultivated in our gardens, as *Papaver*, *Argemone*, *Rœmeria*, *Platystemon*, *Eschscholtzia*, &c. The latter plant is remarkable for its enlarged hollow thalamus, from which the calyx separates by transverse dehiscence in the form of a conical cap, resembling the extinguisher of a candle.

Natural Order 14. FUMARIACEÆ.—The Fumitory Order (*figs.* 856—859). — General Character. — *Smooth Herbs* with a

watery juice. *Leaves* alternate, much divided, exstipulate. *Sepals* 2 (*fig.* 856), deciduous. *Petals* 4, cruciate, very irre-

Fig. 856. *Fig.* 857. *Fig.* 858.

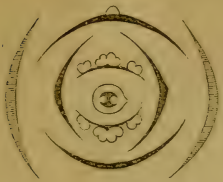


Fig. 859.

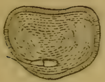


Fig. 856. Diagram of the flower of *Corydalis*, with two sepals, four petals, six stamens in two bundles, and a one-celled pistil.——*Fig.* 857. Vertical section of the flower of *Hypecoum*.——*Fig.* 858. Upper or posterior petal of *Corydalis*, and a bundle of three stamens.——*Fig.* 859. Vertical section of the seed of *Fumaria*.

gular, in two whorls (*fig.* 856); one or both of the outer petals saccate or spurred (*fig.* 858), the two inner frequently united at the apex. *Stamens* hypogynous, usually 6, diadelphous, the two bundles being opposite the outer petals, and containing an equal number of stamens (*figs.* 856 and 858), the middle stamen of each bundle having a 2-celled anther (*fig.* 856), the two outer with 1-celled anthers; rarely 4 stamens, which are then distinct and opposite the petals. *Ovary* superior (*fig.* 857), 1-celled (*fig.* 856); *style* filiform; *stigma* with two or more points; *ovules* amphitropal. *Fruit* either indehiscent and 1 or 2-seeded; or two-valved, dehiscent (*fig.* 857), or a succulent indehiscent pod-like fruit; in the two latter cases containing a number of seeds. *Seeds* shining, crested; *embryo* abaxial, minute (*fig.* 859); *albumen* fleshy.

Diagnosis. — Smooth herbs, with a watery juice, and alternate, exstipulate, much divided leaves. Flowers very irregular and unsymmetrical, and either purple, white, or yellow. Sepals 2, deciduous. Stamens hypogynous, usually 6, diadelphous, or 4, distinct, always opposite to the petals. Ovary superior with parietal placentas; ovules horizontal, amphitropal. Embryo minute, abaxial, in fleshy albumen.

Distribution, &c. — The plants of this order principally occur in thickets and waste places in the temperate latitudes of the northern hemisphere. *Examples:*—Hypecoum, Dicentra, Corydalis, Fumaria. There are 15 genera, including 110 species.

Properties and Uses. — They possess slightly bitter, acrid, astringent, diaphoretic, emmenagogue, and aperient properties;

but these are unimportant, and require no special notice. Some species are cultivated in our gardens and greenhouses. The most important of these is *Dicentra* (*Dielytra*) *spectabilis*, which has very showy flowers, but, like all other plants of the order, it is scentless.

Natural Order 15. CRUCIFERÆ OR BRASSICACEÆ. — The Cruciferous or Cabbage Order (*figs.* 860—867). — General Character. — *Herbs*, or very rarely shrubby plants. *Leaves* alternate, exstipulate. *Flowers* usually yellow or white, rarely purple, or some mixture of these colours; *inflorescence* racemose (*fig.* 861), or corymbose; usually ebracteated. *Sepals* 4 (*fig.* 860), deciduous; *æstivation* imbricate or rarely valvate. *Petals* 4 (*figs.* 421 *p*, and 860), hypogynous, arranged in the form of a Maltese cross, alternate with the sepals, deciduous. *Stamens* 6, tetradynamous (*fig.* 862, *ec*), hypogynous. *Thalamus* furnished with small green glands (*figs.* 422 and 862 *gl*), placed between the stamens. *Ovary* superior (*fig.* 862), with two parietal placentas (*fig.* 860), 1-celled, or more usually 2-celled (*fig.* 860), from the formation of a spurious dissepiment called the *replum* (*figs.* 600 *cl*, and 863); *style* none (*fig.* 862); *stigmas* 2 (*fig* 864), opposite the placentas. *Fruit* a siliqua (*figs.* 666 and 863), or silicula (*figs.* 864 and 865), 1 or 2-celled, 1 or many-seeded. *Seeds* stalked, generally pendulous (*fig.* 863); *embryo* with the radicle variously folded upon the cotyledons (*figs.* 755, 756, 866, and 867); *albumen* none.

Diagnosis. — Herbs. Bracts generally absent. Sepals and petals 4, deciduous, regular, the latter cruciate. Stigmas 2, opposite to the placentas. Stamens tetradynamous. Fruit a siliqua or silicula. Seed without albumen, and with the radicle variously folded upon the cotyledons. *No other order is likely to be confounded with this if ordinary care be taken, as tetradynamous stamens only occur here, except in a very few plants belonging to the natural order Capparidaceæ.* (See CAPPARIDACEÆ.)

Division of the Order, and Examples of the Genera. — This large and truly natural order has been divided into sub-orders according to the nature of the fruit, and also as to the mode in which the embryo is folded. The sub-orders founded on the nature of the fruit are as follows:—

Sub-order 1. *Siliquosæ.* Fruit a siliqua (*fig.* 863), opening by valves longitudinally (*fig.* 666). *Examples:*— Cheiranthus, Brassica.

Sub-order 2. *Siliculosæ latiseptæ.* Fruit a silicula opening by valves; the replum in its broader diameter (*fig.* 865). *Examples:*— Cochlearia, Armoracia.

Sub-order 3. *Siliculosæ angustiseptæ.* Fruit a silicula opening by valves; the replum in its narrower diameter (*fig.* 864), *Examples:* — Thlaspi, Iberis.

Sub-order 4. *Nucumentaceæ.* Fruit an indehiscent silicula,

Fig. 860.

Fig. 861.

Fig. 863.

Fig. 862.

Fig. 864.

Fig. 865.

Fig. 867.

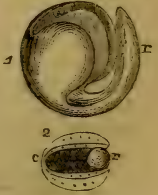


Fig. 866.

Fig. 860. Diagram of a Cruciferous flower.——*Fig.* 861. Portion of the flowering branch of the Wallflower.——*Fig.* 862. Essential organs of the Wallflower (*Cheiranthus Cheiri*). *r.* Receptacle or thalamus. *gl.* Glands. *e, c.* Tetradynamous stamens. *sti.* Stigma.——*Fig.* 863. Siliqua of the Wallflower, with one of the valves removed to show the replum, and the seeds attached by funiculi.——*Fig.* 864. The silicula of Shepherd's Purse (*Thlaspi Bursa Pastoris*) in the act of dehiscing.——*Fig.* 865. Silicula of the Scurvy-grass (*Cochlearia officinalis*) in the act of dehiscing.——*Fig.* 866. The embryo of *Bunias orientalis.*——*Fig.* 867. The embryo of the Cabbage (*Brassica oleracea*). 1. Undivided. 2. Horizontal section. *r.* Radicle. *c.* Cotyledons.

often 1-celled, owing to the absence of the replum. *Example:* — Isatis.

Sub-order 5. *Septulatæ.* — The valves of the fruit opening longitudinally, and bearing transverse septa in their interior. No examples among British plants.

Sub-order 6. *Lomentaceæ.* — Fruit a siliqua or silicula, dividing transversely into 1-seeded portions, the true siliqua sometimes barren; the beak placed above it containing one or two seeds. *Examples:* — Cakile, Raphanus.

These sub-orders are further sub-divided into Tribes, according to the mode of folding of the embryo.

The sub-orders founded on the mode in which the embryo is folded, which was first adopted by De Candolle, and which is more generally used, is as follows: —

Sub-order 1. *Pleurorhizeæ* (○ =) (*fig.* 756). — Cotyledons accumbent, flat; radicle lateral. *Examples:* — Cheiranthus, Nasturtium, Arabis.

Sub-order 2. *Notorhizeæ* (○ ||) (*fig.* 755). — Cotyledons incumbent, flat; radicle dorsal. *Examples:* — Hesperis, Sisymbrium, Isatis.

Sub-order 3. *Orthoploceæ* (○ ≥) (*fig.* 867). — Cotyledons conduplicate, longitudinally folded in the middle; radicle dorsal, within the fold. *Examples:* — Brassica, Sinapis, Raphanus.

Sub-order 4. *Spirolobeæ* (○ || ||) (*figs.* 754 and 866). — Cotyledons twice folded, linear, incumbent. *Examples:* — Bunias, Erucaria.

Sub-order 5. *Diplecolobeæ* (○ || || ||). — Cotyledons thrice folded, linear, incumbent. *Examples:* — Senebiera, Subularia.

Distribution and Numbers. — The plants of this order chiefly inhabit temperate climates. A large number are also found in the frigid zone, and a few in tropical regions chiefly on mountains. Lindley enumerates 195 genera, including about 1600 species.

Properties and Uses. — This order is generally characterised by antiscorbutic and pungent properties, frequently combined with acridity. The order is one of the most natural in the Vegetable Kingdom, and does not contain a single poisonous plant. The seeds frequently contain a fixed oil. Many of our commonest culinary vegetables are derived from it. The Cruciferæ are also interesting in a chemical point of view, as many of them contain much nitrogen and sulphur, and, according to Mulder, the common Water-cress (*Nasturtium officinale*) contains iodine. The more interesting plants are the following: —

Nasturtium officinale. — This plant is the common Water-cress, so well known as an excellent and wholesome salad.

Cardamine pratensis, Cuckoo-flower. — The flowers were formerly much

used for their stimulant and diaphoretic properties, and have long been a popular remedy for epilepsy in children.

Cochlearia officinalis, Scurvy-grass.—This plant was long esteemed for its antiscorbutic properties.

Armoracia rusticana (*Cochlearia Armoracia*).—The root is the common horse-radish, so much used as a condiment. Some lamentable cases of poisoning have occurred from the substitution of Aconite or Monk's-hood root for that of Horse-radish, which it is supposed to resemble. (See *Pharmaceutical Journal*, vol. xv. p. 419.) Fresh Horse-radish is also used in medical practice: *externally*, as an irritant, rubefacient, and vesicant; and *internally*, as a stimulant, diuretic, and masticatory. Its virtues depend upon the presence of a small quantity of volatile oil, which is almost dissipated by drying; hence Horse-radish should always be used in a fresh state.

Anastatica hierochuntina, Rose of Jericho.—This plant, which is found wild in the deserts of Egypt and Syria, is remarkable for possessing hygrometric properties. Thus, when full grown, and its branches have become dry and withered, it contracts and coils up, so as to assume the form of a ball, in which state it is blown about by the winds from place to place; but if it be then exposed to moisture, it uncoils, and the branches expand again, as if the life of the plant was renewed. "Some superstitious tales are told of it, among which, it is said to have first bloomed on Christmas Eve to salute the birth of the Redeemer, and paid homage to His resurrection by remaining expanded till Easter."

Camelina sativa, Gold of Pleasure.—The seeds contain much fixed oil.

Lepidium sativum, Garden Cress.—This is well known as a pungent salad; it is commonly used with the young herb of the Mustard plants.

Isatis tinctoria, Woad.—This herb yields a dark-blue dye, which was formerly much used in this country and other parts of Europe, but it is now rarely or ever employed, its use having been superseded by Indigo. In China also, a blue dye is obtained from the fruits of *Isatis indigotica*

Brassica.—This genus contains several species which are commonly cultivated as food for man and cattle. Thus:—*Brassica Rapa*. is the common Turnip. The Swedish Turnip is probably a hybrid between *Brassica campestris* and *B. Rapa*, or *Napus*; according to others, it is derived from *B. campestris*. *B. Napus*, yields Rape, Cole, or Colza-seeds, from which may be expressed a large quantity of bland fixed oil, which is now much used for burning and other purposes. The cake left after the expression of the oil is also used as food for cattle, &c., under the name of Oil-Cake. The seeds of *B. chinensis* yield Shanghae Oil. *B. oleracea* is supposed to be the original species from which have been derived by cultivation, all the varieties of Cabbages. Kohl-Rabi, Greens, Brocoli, and Cauliflowers. The Kohl-Rabi is produced by the stem enlarging above the ground into a fleshy knob, resembling a turnip. Brocoli and Cauliflowers are deformed inflorescences.

Sinapis.—The seeds of two species of this genus are in common use in medicine and for culinary purposes. and the young herbs are also employed as salads. These species are, *Sinapis nigra* and *S. alba*. The seeds of the former are dark-coloured, and are known as Black Mustard seeds; those of the latter are of a yellowish colour, and are termed White Mustard seeds. It was formerly supposed, that flour of mustard, so extensively used as a condiment, was prepared solely from black mustard seeds, but it is now ascertained that it is derived from a mixture of commonly two parts of black and three of white mustard seeds. Both the black and white mustards seeds contain a large quantity of fixed oil, which is readily obtained by submitting them to pressure; this expressed oil is called fixed oil of mustard. It is remarkable that we do not find in either the black or white seeds the pungent acrid principle for which mustard is distinguished. But when black mustard seeds are distilled with water, they yield a very acrid and pungent volatile oil, on which their virtues depend. The elements of this oil only, exist in the seed, in the forms of Myronic acid, and Myrosyne. These substances, when mixed through the medium of water, form the volatile oil of black mustard. The active properties of white mustard-seeds are not due to the presence of a volatile oil, as no such oil can be obtained from them by distillation with water, or otherwise; but they are owing to a fixed pungent and acrid principle, which does not pre-exist in the seeds, but only its elements in the form of Sinapin or Sinapisin, and a substance resembling vegetable albumen or emulsin. These, when brought together under the influence of water, produce the fixed acrid principle of white mustard seeds. Internally, flour of mustard is used as a stimulant, diuretic, and emetic;

and externally applied, it is irritant, rubefacient, &c. White mustard seeds are also taken in an entire state as stimulants in dyspepsia.

Crambe maritima, Sea-Kale.—The stem and leaf-stalks of this plant by cultivation, form a delicious vegetable. In the wild state the plant possesses a good deal of acridity, which is almost entirely removed by cultivation.

Raphanus sativus.— This is the common Radish so much employed as a salad, &c.

Many plants of the order are favourite objects of culture in our gardens, such as the Stock (*Matthiola*), Wall-flower (*Cheiranthus Cheiri*), Candy Tuft (*Iberis umbellata*), Honesty (*Lunaria biennis*), &c.

Natural Order 16. CAPPARIDACEÆ.—The Caper Order.—General Character.—*Herbs, shrubs*, or rarely *trees*. *Leaves* alternate, exstipulate, or rarely with spiny stipulate appendages. *Sepals* 4 (*fig.* 642, *cal*), sometimes cohering more or less; *æstivation* imbricate or valvate, equal or unequal. *Petals* usually 4 (*fig.* 642, *cor*), cruciate, imbricate, generally unequal and unguiculate, rarely 8, or sometimes none. *Stamens* numerous, or definite, if 6, very rarely tetradynamous, placed upon a prolonged thalamus or stalk by which they are raised above the corolla (*fig.* 642, *st*). *Ovary* placed on a gynophore (*fig.* 642, *ov*), or sessile, 1-celled; *placentas* 2 or more, parietal; *style* filiform or wanting; *ovules* amphitropal or campylotropal. Fruit 1-celled, usually many-seeded, very rarely 1-seeded, either pod-shaped and dehiscent, or baccate and indehiscent. Seeds generally reniform, without albumen; *embryo* curved; *cotyledons* leafy.

Diagnosis.—Herbs, shrubs, or trees, with alternate leaves. Sepals and petals 4 each, the latter cruciate, and generally unequal Stamens usually numerous, very rarely tetradynamous, inserted on a stalk, which raises them above the corolla. Ovary 1-celled, placentas parietal. Fruit dehiscent or indehiscent, 1-celled. Seeds generally reniform; embryo curved; no albumen.

Division of the Order, and Examples of the Genera.—The order is divided into two sub-orders, according to the nature of the fruit, as follows:—

Sub-order 1. *Cleomeæ.*—Fruit capsular. *Examples:*—Gynandropsis, Cleome, Physostemon.

Sub-order 2. *Cappareæ.*—Fruit baccate. *Examples:*—Cadada, Capparis.

Distribution and Numbers.—The plants of the order Capparidaceæ are chiefly found in tropical and sub-tropical regions of the globe. In Africa they are especially abundant. The common Caper (*Capparis spinosa*), which inhabits rocky places in the south of Europe, is the only European species of this order, and also that one which is found farthest north. There are 28 genera, and 340 species.

Properties and Uses.—In their properties the plants of this order resemble in many respects the Cruciferæ, being generally pungent, stimulant, and antiscorbutic. Some are aperient, diuretic, and anthelmintic. In some plants the pungent principle is so concentrated, or probably is in itself deleterious, that

they are very poisonous. The more important plants are as follows:—

Cleome.—Some species are very pungent, and are used as condiments like our mustard.

Polanisia.—Some species of this genus are also employed like mustard. The root of *P. icosandra* is used internally as a vermifuge, and externally as a rubefacient, &c.

Cadaba indica.—The root is reputed to be aperient and anthelmintic

Capparis.—The flower-buds of various species of this genus are used to form the well-known pickle called Capers. Thus: *Capparis spinosa*, is that employed in the South of Europe, *C. Fontanesii* in Barbary, and *C. ægyptiaca* in Egypt. *C. ægyptiaca* is stated to be the Hyssop of Scripture. Capers are stimulant, antiscorbutic, and aperient. The fruit of one species, said to be allied to *C. pulcherrima*, and which is found in the neighbourhood of Carthagena, is extremely poisonous.

Natural Order 17. RESEDACEÆ.—The Mignonette Order.—General Character.—*Herbs*, or rarely small *shrubs*. *Leaves* alternate, entire or divided, with glandular appendages at their base. *Calyx* with from 4—7 divisions. *Petals* 2—7, lacerated (*fig.* 484), unequal. *Disk* fleshy, hypogynous, one-sided. *Stamens* definite, inserted on the disk. *Ovary* sessile, 1-celled (*fig.* 606); *placentas* 3 (*fig.* 606, *pl*), or 6, parietal; *stigmas* 3, sessile. *Fruit* opening at the apex long before the seeds are ripe (*fig.* 650), 1-celled, and with 3 or 6 parietal placentas; or consisting of empty carpels surrounding a central placenta. *Seeds* usually numerous, reniform; embryo without albumen.

Diagnosis.—Usually herbs, with alternate leaves and unsymmetrical flowers. Disk large, hypogynous, one-sided. Stamens definite, not tetradynamous. Ovary sessile, 1-celled; placentas 3—6, parietal; stigmas 3, sessile. Fruit usually opening early at its apex. Seeds usually numerous, reniform, exalbuminous.

Distribution, &c.—They are chiefly natives of Europe and the adjoining parts of Africa and Asia. A few occur in the north of India, Cape of Good Hope, and California. *Example:*—Reseda. There are 6 genera, and 41 species.

Properties and Uses.—But little is known of their properties. They are generally somewhat acrid, and were formerly supposed to be sedative. The only genus of importance is:—

Reseda.—Thus *Reseda odorata* is the Mignonette plant which is so much esteemed for the fragrance of its flowers. *Reseda luteola*, a common plant in this country, and known under the name of Weld, yields a yellow dye.

Natural Order 18. CISTACEÆ.—The Rock-Rose Order (*figs.* 868 and 869).—General Character.—*Shrubs* or *herbs*, often viscid. *Leaves* opposite or alternate, entire, stipulate or exstipulate. *Flowers* showy. *Sepals* usually 5 (*fig.* 868), sometimes 3, persistent, unequal; *æstivation* of the three inner twisted. *Petals* usually 5 (*fig.* 868), very rarely 3, caducous, hypogynous, frequently corrugated in the bud, and twisted in a reverse way to that of the sepals. *Stamens* (*fig.* 868) distinct, hypogynous, definite or indefinite. *Ovary* 1 (*fig.* 868) or many-celled; *style* single; *stigma* simple. *Fruit* capsular, usually 1-celled, with

3—5, or rarely 10 valves; or imperfectly 3—5—10-celled; *placentas* parietal (*fig.* 868). *Seeds* definite or numerous, albuminous (*fig.* 869); *embryo* (*fig.* 869) curved or spiral, with the radicle remote from the hilum.

Fig. 868.

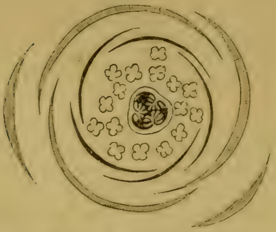


Fig. 869.

Fig. 868. Diagram of the flower of a species of *Helianthemum*.—*Fig.* 869. Section of the seed of a species of *Cistus*, the pointed end being its apex.

Diagnosis.—Leaves entire. Sepals and petals with a ternary or quinary arrangement, twisted in æstivation; the former persistent, the latter caducous. Stamens hypogynous, distinct. Ovary with parietal placentas; style single; stigma simple. Fruit capsular. Seeds with mealy albumen; embryo inverted, curved or spiral.

Distribution, &c.—These plants are most abundant in the south of Europe and the north of Africa. Some few are found in other parts of the globe. *Examples:*—Cistus, Helianthemum. There are 7 genera, and 185 species.

Properties and Uses.—These plants have generally resinous and balsamic properties. Some are regarded as stimulant and emmenagogue. The more important plants of the order are:—

Cistus creticus.—The fragrant resinous substance called Ladanum is obtained from the above plant in the Levant, and also from *C. Ladaniferus*, *C. Ledon*, &c. It has been used as a stimulant, expectorant, and emmenagogue. It is also much esteemed by the Turks as a perfume, and for fumigation.

Cochlospermum Gossypium.—According to Royle, the trunk of this plant yields the gum Kuteera, which in the north-western provinces of India &c., is substituted for Tragacanth.

Natural Order 19. Bixaceæ or Flacourtiaceæ.—The Annatto or Arnatto Order.—General Character.—*Shrubs* or small *trees*. *Leaves* alternate, exstipulate, usually entire and leathery, and very often dotted. *Sepals* 4—7, somewhat united at the base. *Petals* hypogynous, distinct, equal in number to the sepals and alternate with them, sometimes absent. *Stamens* hypogynous, of the same number as the petals, or some multiple of them. *Ovary* 1 or more celled, sessile or slightly stalked; *placentas* 2 or more, parietal, sometimes branched so as to form

a network over the inner surface of the ovary and fruit. *Fruit* 1-celled, dehiscent or indehiscent, having a thin pulp in its centre. *Seeds* numerous, usually enveloped in a covering formed by the withered pulp; *albumen* fleshy-oily; *embryo* straight, axial; radicle turned to the hilum.

Diagnosis.—Shrubs or small trees, with alternate exstipulate leaves, dotless, or with round dots. Flowers polypetalous or apetalous; petals hypogynous. Stamens hypogynous, equal in number to the petals, or some multiple of them. Fruit dehiscent or indehiscent; placentas parietal, and sometimes forming a network over the inner surface of the fruit. Seeds numerous, albuminous; embryo axial, straight; radicle towards the hilum.

Distribution, &c.—The plants of this order are almost confined to the hottest parts of the East and West Indies, and Africa. *Examples:*—Bixa, Oncoba, Aphloia, Flacourtia, Erythrospermum. There are 34 genera, and about 90 species.

Properties and Uses.—Many plants of the order are feebly bitter and astringent, and have been used as stomachics. The bark of *Aphloia* is said to be emetic. The fruits of *Oncoba* and of some of the *Flacourtias* are edible and wholesome The most important plant of the order is

Bixa Orellana.—The seeds of this plant are covered by a reddish pulp, from which Arnatto or Annatto, is made. This is used as a red dye, and for colouring cheese and chocolate. The seeds are said to be cordial, astringent and febrifugal.

Natural Order 20. VIOLACEÆ.—The Violet Order (*figs.* 870 and 871).—General Character.—*Herbs* or *shrubs.* *Leaves* simple, stipulate (*fig.* 356), with an involute vernation, alternate, or sometimes opposite. *Sepals* 5 (*fig.* 775), persistent, imbricate, usually prolonged at the base. *Petals* 5 (*fig.* 775), hypogynous, equal or unequal, one usually spurred. *Stamens* equal in number to the petals (*fig.* 775), and usually alternate with them, or rarely opposite, inserted on a hypogynous disk, often unequal; *anthers* 2-celled, sometimes united (*fig.* 870), bursting inwards; *filaments* short and broad (*fig.* 870), and elongated, so as to project beyond the anthers (*fig* 514); when the flowers are irregular, two of the anthers are spurred at the

Fig. 870.

Fig. 871.

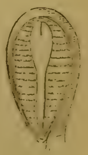


Fig. 870. Essential organs of the Pansy (*Viola tricolor*). *st.* Obliquely hooded stigma. *a.* United anthers, two having long appendages below.——*Fig.* 871. Vertical section of the seed of the Pansy.

base (*fig.* 870). *Ovary* 1-celled, with 3 parietal placentas (*fig.* 775); *style* single, usually declinate (*fig.* 429); *stigma* capitate, oblique, hooded (*fig.* 870, *st*); *ovules* usually numerous (*fig.* 429, *o, o*). *Fruit* capsular, 3-valved (*fig.* 665), dehiscence loculicidal; placentas on the middle of the valves. *Seeds* usually numerous (*fig.* 665), sometimes definite; *embryo* straight, erect, in the axis of fleshy albumen (*fig.* 871).

Diagnosis. — Herbs or shrubs. Leaves simple, stipulate, and with involute vernation. Flowers regular or irregular. Sepals, petals, and stamens, 5 each, hypogynous. Stamens all perfect; anthers introrse with the filaments prolonged beyond them. Ovary 1-celled, with 3 parietal placentas opposite the 3 outer sepals; style and stigma single. Fruit 1-celled, dehiscing by 3 valves, each valve bearing a placenta in its middle. Seeds having a straight erect embryo in the axis of fleshy albumen.

Division of the Order, and Examples of the Genera.—The order has been divided into two sub-orders as follows: —

Sub-order 1. *Violeæ.* — Having irregular flowers, and appendaged anthers. *Examples:* — Viola, Ionidium.

Sub-order 2. *Alsodeæ.* — With regular flowers, and anthers not furnished with appendages. *Examples:* — Alsodeia, Pentaloba.

Distribution and Numbers.—The herbaceous plants of the sub-order Violeæ are chiefly natives of Europe, Siberia, and North America; the shrubby mostly of South America. The Alsodeæ are exclusively natives of South America, Africa, and Malacca. There are 15 genera, and about 300 species belonging to the order Violaceæ.

Properties and Uses. — The plants of this order are chiefly remarkable for emetic and purgative properties. A few also are mucilaginous, and others have been reputed anodyne. The emetic property is due to a peculiar alkaloid named *violine*, which greatly resembles, if it be not identical with, *emetine*, the active principle of the true Ipecacuanha root. This principle is more especially found in some of the shrubby South American species, but it also occurs, to some extent at least, in many of the herbaceous European species. The plants of this order deserve further trial as medicinal agents in this country. The following are the more important: —

Viola odorata, the March or Sweet Violet. — The flowers of this plant have been always highly esteemed for their fragrance. An infusion or syrup of the petals is a useful chemical test, as the violet or purplish colour is changed into red by acids, and green by alkalies. The syrup is officinal, and is employed partly on account of its colour and odour, but chiefly as a laxative for very young children. The flowers were formerly regarded as anodyne. The roots, stems, and seeds have been also regarded as emetic and purgative. They contain *violine*. *Viola canina*, the Dog Violet, is said to be very efficacious in cutaneous diseases. *Viola tricolor*, a common indigenous plant, is the origin of all our cultivated varieties of Pansies or Heart's-ease. The Violets generally, have been used on the Continent, as demulcent expectorants.

Ionidium Ipecacuanha, Woody Ipecacuanha. — The root of this plant was supposed by Linnæus to be the source of the true Ipecacuanha. It is the false

Ipecacuanha of Brazil, and is employed as an emetic in that region. It contains emetine. Other species of *Ionidium*, as *I. parviflorum*, *I. Itubu*, &c., possess similar properties. The roots of *I. parviflorum* (*I. microphyllum*, Humb. & Dec.) constitute the Cuchunchully de Cuença, which is much used in the province of Venezuela as a remedy for elephantiasis.

Natural Order 21. SAUVAGESIACEÆ.—The Sauvagesia Order. — General Character. — This order is by some botanists considered as merely a sub-order of Violaceæ. It is distinguished by its plants, having either 5 perfect stamens alternate with 5 sterile ones, or numerous stamens; if only 5, these are also opposite the petals; the *anthers* are also extrorse, and have no appendages. The fruit also burst septicidally, and hence each valve bears the placentas at its edges.

Distribution, &c. — They are natives chiefly of South America and the West Indies. *Examples:* — Sauvagesia, Lavradia. Lindley enumerates 3 genera, and 15 species.

Properties and Uses. — But little is known of the properties of this order. The *Sauvagesia erecta* contains a good deal of mucilaginous matter, and has been used internally as a diuretic, and in inflammation of the bowels, and also externally, in diseases of the eye.

Natural Order 22. DROSERACEÆ. — The Sun-dew Order. — General Character. — Herbaceous plants growing in boggy or marshy places, frequently glandular. *Leaves* alternate, fringed at their base (*fig.* 352), and with a circinate vernation. *Peduncles* when young, circinate. *Sepals* and *petals* 5, hypogynous, equal, imbricated, persistent. *Stamens* as many as the petals and alternate with them, or twice, thrice, or four times as many, distinct, withering, hypogynous; *anthers* extrorse. *Ovary* 1-celled, superior; *styles* 3—5, distinct, or connected at the base; *ovules* numerous, anatropal. *Fruit* capsular, 1-celled, bursting by 3 or 5 valves, which bear the placentas in their middle or base; hence the dehiscence is loculicidal. *Seeds* numerous, with or without an aril; *embryo* minute, at the base of abundant fleshy albumen.

Diagnosis. — Bog or marsh herbs, frequently furnished with glands, and with alternate exstipulate leaves, with a circinate vernation. Peduncles when young, circinate. Flowers regular and symmetrical, hypogynous, with a quinary arrangement of their parts, which are also persistent and imbricate. Anthers extrorse. Styles several; placentas parietal. Fruit capsular, 1-celled, with loculicidal dehiscence. Seeds numerous; embryo small at the base of copious fleshy albumen.

Distribution, &c. — These plants are found in almost all parts of the world, with the exception of the Arctic regions. They inhabit bogs or marshy districts. *Examples:* — Drosera, Aldrovanda, Dionæa. According to Lindley, there are 7 genera, and 90 species, but Planchon, who has written a memoir upon this order, only enumerates 6 genera, and 90 species.

Properties and Uses. — They possess slightly acid and acrid

properties. Some of the *Droseras* are said to be poisonous to cattle, but there is no satisfactory proof of such being the case. It has been supposed that some of the *Droseras* would yield valuable dyes, because they communicate a brilliant purple stain to the paper upon which they are dried, and also from the circumstance of yielding a yellow colour when treated with ammonia. The plants of the order are, however, chiefly interesting from the peculiar irritability of the hairs on their leaves. Thus the Sun-dews (*Droseras*), are fringed with beautiful glandular hairs, which close more or less in different species when insects alight upon them; while *Dionæa muscipula* (*fig.* 352), a native of North America, has two-lobed leaves, each of which is furnished on its upper surface with three stiff hairs, which, when touched, cause the two halves of the leaf to collapse and enclose the object touching them. This plant is sometimes cultivated in our stoves, and is commonly known as Venus's Fly-trap.

Natural Order 23 FRANKENIACEÆ.—The Frankenia Order.—General Character.—*Herbs* or *undershrubs*, much branched. *Leaves* opposite, exstipulate, with a membranous sheathing base. *Flowers* sessile. *Calyx* tubular, with 4 or 5 divisions, equal, persistent. *Petals* 4 or 5, distinct, imbricate, often appendaged, unguiculate, hypogynous. *Stamens* 4 or 5, or twice as many as the petals, hypogynous, distinct; *anthers* versatile. *Ovary* 1-celled, superior; *style* 2, 3, or 4-fid; *ovules* numerous, anatropal; *placentas* parietal. *Fruit* capsular, 1-celled, many-seeded, 2, 3, or 4-valved, enclosed in the calyx. *Seeds* numerous, very minute; *embryo* straight, erect, in the middle of albumen.

Diagnosis.—Herbs or undershrubs, much branched, with opposite exstipulate leaves, and sessile flowers. Calyx tubular, furrowed, persistent. Petals unguiculate, 4 or 5, hypogynous. Stamens hypogynous, distinct. Ovary superior, 1-celled, with parietal placentas. Fruit capsular, 1-celled, enclosed in the calyx, and dehiscing in a septicidal manner. Seeds numerous; embryo straight, erect, in the middle of albumen.

Distribution, &c.—The plants of this order are scattered over the globe, except in tropical India and North America, but they chiefly occur in the south of Europe and north of Africa. *Examples:*—Frankenia, Beatsonia. There are 4 genera, and 24 species mentioned by Lindley.

Properties and Uses.—Unimportant. They have been reputed mucilaginous and slightly aromatic. The leaves of a species of *Beatsonia* are used at St. Helena as a substitute for tea.

Natural Order 24. TAMARICACEÆ.—The Tamarisk Order. General Character.—*Shrubs* or *herbs*. *Leaves* alternate, scaly, entire, usually pitted. *Flowers* in spikes or racemes. *Calyx* 4 or 5-parted, persistent, imbricate. *Petals* distinct, adherent to

the calyx, withering, imbricate. *Stamens* hypogynous, as many as the petals, or twice as numerous, distinct or united ; *anthers* introrse. *Ovary* superior; *styles* 3 ; *ovules* numerous. *Fruit* 1-celled, dehiscing by 3 valves in a loculicidal manner ; hence each valve bears a placenta in its middle, or sometimes at its base. *Seeds* numerous, comose, exalbuminous ; *embryo* straight ; *radicle* next the hilum.

Diagnosis. — Shrubs or herbs, with alternate entire scale-like leaves. Calyx 4—5, parted, imbricate, persistent. Petals distinct, and attached to the calyx, withering, imbricate. Stamens hypogynous; anthers introrse. Ovary superior with distinct styles. Fruit dehiscing by 3 valves, each of which bears a placenta at its middle or base. Seeds numerous, comose, without albumen, and having a straight embryo, with the radicle towards the hilum.

Distribution, &c. — The plants of this order usually grow by the sea-side, or sometimes on the margins of rivers or lakes. They are most abundant in the basin of the Mediterranean, and are altogether confined to the northern hemisphere of the Old World. *Examples:*— Tamarix, Myricaria. There are 3 genera, and 43 species.

Properties and Uses. — The bark of these plants is astringent, slightly bitter, and tonic. The ashes of some species of *Tamarix* contain much sulphate of soda.

Tamarix mannifera produces a saccharine substance, which is known under the name of Mount Sinai Manna. This is considered by Ehrenberg, as an exudation produced by a species of Coccus, which inhabits this plant. Several species of *Tamarix* are liable to the attack of insects, which produce galls on their surface. These galls are astringent, and are used in those cases where astringent substances are required, in medicine, and in dyeing. *Myricaria germanica*, is a common ornamental shrub in our gardens; and *Tamarix gallica* is also commonly seen in our gardens, and growing apparently wild on the south-west coast of this country.

Natural Order 25. ELATINACEÆ. — The Water-Pepper Order. — General Character. — Little annual marsh plants, with hollow creeping stems. *Leaves* opposite, with interpetiolar membranaceous stipules. *Flowers* minute, axillary. *Sepals* and *petals* 3—5, imbricated, the latter hypogynous and alternate with the sepals. *Stamens* hypogynous, generally double the number, or sometimes only as numerous as the petals, distinct. *Ovary* superior, 3—5-celled; *styles* 3—5; *stigmas* capitate; *ovules* numerous, anatropal. *Fruit* capsular, 3—5-celled, 3—5-valved, dehiscence loculicidal; *placentas* axile. *Seeds* numerous, without albumen, wrinkled ; *embryo* straight ; *radicle* towards the hilum.

Diagnosis. — Little annual plants, with hollow stems, and opposite leaves with interpetiolar stipules. Flowers small and axillary. Sepals and petals 3—5, the latter, as well as the stamens, being hypogynous. Fruit capsular, 3—5-celled, placentation axile. Styles 3—5 ; stigmas capitate. Seeds numerous, exalbuminous ; embryo straight.

Distribution, &c. — The plants of this small order are scattered all over the world. *Examples* : —Elatine, Bergia, Merimea. Lindley enumerates 6 genera, and 22 species.

Properties and Uses. — They are generally considered acrid, hence the English name of the order.

Natural Order 26. CARYOPHYLLACEÆ.—The Pink or Clovewort Order (*figs.* 872—876). — General Character. — *Herbs.* *Stems* swollen at the joints. *Leaves* opposite, entire, exstipulate, often united at their base. *Inflorescence* various, cymose (*fig.* 411). *Flowers* hermaphrodite, or rarely unisexual. *Sepals* 4 or 5 (*fig.* 872), distinct, or coherent into a tube (*fig.* 445), persistent. *Petals* equal in number to the sepals (*fig.* 872), hypogynous, un-

Fig. 872.

Fig. 873.

Fig. 875.

Fig. 876.

Fig. 874.

Fig. 872. Diagram of the flower of a species of *Dianthus*.——*Fig.* 873. Vertical section of the flower of a species of *Dianthus*.——*Fig.* 874. Essential organs of *Stellaria*.——*Fig.* 875. Capsule of *Dianthus*, dehiscing by four valves at the apex. ——*Fig.* 876. Vertical section of the seed of Chickweed (*Stellaria*).

guiculate (*fig.* 461), often deeply divided (*fig.* 460), sometimes absent, frequently raised above the calyx on a stalk (*fig.* 873). *Stamens* equal in number to the sepals, and then either alternate or opposite to them, or usually twice as numerous (*figs.* 872 and 874), or rarely fewer, frequently attached with the petals on a stalk above the calyx (*fig.* 873); *filaments* generally distinct (*fig.* 874), sometimes united at the base, subulate; *anthers* innate. *Ovary* sessile (*fig.* 874), or supported with the petals and stamens on a short gynophore (*figs.* 587, *g*, and 873), 1-celled generally (*figs.* 618 and 619), or rarely 2—5-celled (*figs.*

617 and 872); *styles* 2 (*fig.* 587) to 5 (*fig.* 618), papillose on their inner surface (*fig.* 587), and hence should properly be regarded as stigmas; *ovules* few or numerous, amphitropal. *Fruit* a 1-celled capsule, opening by 2—5 valves (*fig.* 875), or by 4—10 teeth, at the apex (*fig.* 648), and having a free central placenta (*fig.* 618, *pl.*), or rarely 2—5-celled with a loculicidal dehiscence, and with the placentas slightly attached to the dissepiments. *Seeds* usually numerous (*fig.* 618), rarely few; *embryo* curved round the albumen which is of a mealy character (*figs.* 760 and 876).

Diagnosis.—Herbaceous plants with stems swollen at the joints, and opposite, entire, exstipulate leaves. Flowers usually hermaphrodite. Sepals, petals, and stamens, with a quaternary or quinary arrangement, the petals sometimes absent Stamens hypogynous; anthers innate. Ovary commonly 1-celled; styles 2—5. Capsule 1-celled, or rarely 2—5-celled; placenta usually free central, sometimes in the 2—5-celled fruit slightly attached to the dissepiments. Seeds with the embryo curved round mealy albumen.

Division of the Order, &c.—The order is divided into three sub-orders, as follows:—

Sub-order 1. *Alsineæ*, the Chickweed Sub-order.—Sepals distinct, and opposite the stamens, when the latter are equal to them in number. *Examples:*—Alsine, Arenaria, Stellaria, Cerastium.

Sub-order 2. *Sileneæ*, the Pink Sub-order.—Sepals cohering into a tube, and opposite the stamens, when the latter are equal to them in number. *Examples:*—Dianthus, Saponaria, Silene, Lychnis.

Sub-order 3. *Mollugineæ*, the Carpet-weed Sub-order.—Sepals distinct or nearly so, and alternate with the stamens, when the latter are equal to them in number; if the stamens are fewer than the sepals, they are then alternate with the carpels. *Examples:*—Mollugo, Cælanthum.

Distribution, &c.—They are natives chiefly of temperate and cold climates. When found in tropical regions they are generally on the sides and summits of mountains, commonly reaching the limits of eternal snow. According to Lindley, there are 59 genera, and 1055 species.

Properties and Uses.—The plants of this order possess no important properties. They are almost always insipid. Some of the wild species are eaten as food by small animals, and some have been said to increase the lacteal secretions of cows fed upon them. This is supposed to be the case more particularly with *Vaccaria vulgaris*. *Saponaria officinalis* has been used in syphilis. It contains a peculiar principle called *saponine*. This principle has also been found in species of *Lychnis*, *Silene*, *Cucubalus*,

and especially so in *Gypsophila Struthium*, to which latter plant it communicates well-marked saponaceous properties, hence that is commonly termed Egyptian Soap-root. The other species in which saponine is found also possess, to some extent, similar properties. Saponine is reputed to be poisonous in its nature.

Some of the plants have showy flowers, as the species of *Dianthus*, *Silene*, and *Lychnis*; but they are generally insignificant weeds. *Dianthus barbatus* is the Sweet-William of our gardens; *D. plumarius* is the parent of all the cultivated varieties of the Common Pink; and *D. Caryophyllus*, the Clove-Pink, is the origin of the Carnation and its cultivated varieties, which are known commonly as Picotees, Bizarres, and Flakes. In the *Carnation* the petals are entire and marked with coloured stripes only, there is no break in the colour of the stripes, and they have no dots or small lines on their surface. In the *Picotee* the petals are slightly serrated, and have a number of small lines or dots placed on a white or yellow ground. *Bizarres* are Carnations with a white ground, marked with two or more colours. *Flakes* are Carnations with but one colour.

Natural Order 27. VIVIANIACEÆ. — The Viviania Order. — General Character. — *Herbs* or *undershrubs*. *Leaves* opposite or whorled, exstipulate. *Flowers* regular, white, red, or pink. *Calyx* with 5 divisions and 10 ribs; *æstivation* valvate. *Petals* 5. hypogynous, unguiculate, persistent; *æstivation* twisted. *Stamens* twice as many as the petals, hypogynous; *filaments* distinct; *anthers* 2-celled, bursting longitudinally. *Ovary* superior, 3-celled; *stigmas* 3. *Fruit* capsular, 3-celled, with a loculicidal dehiscence. *Seeds* 2 in each cell; *embryo* curved in fleshy albumen; *radicle* next the hilum.

Diagnosis, &c. — The plants of this order are readily known among the Thalamifloral Exogens by their regular flowers, valvate 10-ribbed calyx, permanent withering corolla, 10 hypogynous stamens with distinct filaments, 2-celled anthers with longitudinal dehiscence, 3-celled capsule with loculicidal dehiscence, and albuminous seeds, with a curved embryo, and radicle next the hilum.

Distribution, &c. — They inhabit Chili and South Brazil. *Examples*: — Cæsarea, Viviania. There are 4 genera, and 15 species.

Properties and Uses. — Apparently unimportant. Lindley says the *Vivianias* would be pretty greenhouse plants if they could be procured.

Natural Order 28. MALVACEÆ. — The Mallow Order (*figs.* 877—880). — General Character. — *Herbs*, *shrubs*, or *trees*. *Leaves* alternate, more or less divided in a palmate manner, stipulate (*fig.* 303). *Flowers* regular, usually axillary, and often surrounded by an involucre or epicalyx (*figs.* 456 and 877). *Sepals*

usually 5 (*figs.* 456 and 877), rarely 3 or 4; more or less coherent at their base (*fig.* 456); *æstivation* valvate. *Petals* hypogynous, equal in number to the divisions of the calyx (*fig.* 877), with a twisted æstivation, either attached to the column formed by the united stamens (*fig.* 878), or free. *Stamens* hypogynous, numerous, monadelphous (*figs.* 537 and 878); *anthers* 1-celled, reniform, with a transverse dehiscence (*fig.* 523). *Ovary* consisting of several carpels (*figs.* 877 and 879), which are apocarpous (*fig.* 879), or united so as to form a compound ovary, with as many cells as there are carpels; *placentas* attached to the ventral sutures or axile (*fig.* 880 *pl*) *styles* equalling the carpels in number (*fig.* 879), united or distinct. *Fruit* either consisting

Fig. 877.

Fig. 878.

Fig. 879.

Fig. 880.

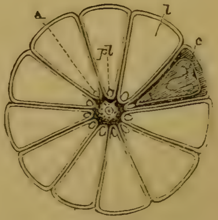


Fig. 877. Diagram of the flower of a species of Mallow. The three external lines represent bracts, and form an epicalyx or involucre.——*Fig.* 878. Vertical section of the flower of a Mallow.——*Fig.* 879. Pistil of Mallow.——*Fig.* 880. Horizontal section of the fruit of *Malva sylvestris*. *a*. Axis. *pl*. Placenta. *l*. An empty cell. *c*. Embryo.

of a number of 1-celled, indehiscent (*figs.* 689 and 880), 1 or many-seeded carpels; or a capsule with loculicidal (*fig.* 657) or septicidal dehiscence, and numerous seeds. *Seeds* sometimes

hairy; *albumen* none, or in small quantity; *embryo* curved; *cotyledons* much twisted (*fig.* 880, *c*).

Diagnosis. — Leaves alternate, simple, stipulate. Regular flowers. Calyx valvate in æstivation. Petals twisted in æstivation. *Stamens* hypogynous, numerous; anthers 1-celled, reniform, opening transversely; filaments united so as to form a column. Carpels distinct or united. Seeds with very little, or no albumen; embryo curved; cotyledons twisted.

Division of the Order, &c. — The order has been divided by Dr. Asa Gray into four tribes: — Malopeæ, Malveæ, Ureneæ, and Hibisceæ. The simplest division, however, for the young student is as follows: —

Tribe 1. *Malveæ.* — Flowers furnished with an involucre or epicalyx (*fig* 877). Fruit consisting of separate carpels, apocarpous (*figs.* 689 and 880). *Examples*: — Malva, Althæa, Lavatera.

Tribe 2. *Hibisceæ.* — Flowers furnished with an involucre (*fig.* 456). Fruit formed by the union of several carpels, syncarpous (*fig.* 657). *Examples*: — Hibiscus, Gossypium.

Tribe 3. *Sideæ.* Flowers without an involucre. Fruit apocarpous or syncarpous. *Example*: — Sida.

Distribution, &c. — The plants of this order are chiefly natives of the tropics and the warmer parts of temperate regions. They diminish gradually as we approach the north, and are altogether absent in the frigid zone. There are 39 genera, which contain about 1000 species.

Properties and Uses. — No plant of this order possesses any deleterious properties. The order is generally characterised by mucilaginous and demulcent qualities. From the liber of many species strong and tough fibres are obtained, and the hairs covering the seed of certain species constitute cotton. Among the more important plants of the order, we may mention more particularly the following: —

Althæa officinalis, Marsh-Mallow.—The root and leaves of this plant abound in mucilage, particularly the root, and hence all preparations from them are demulcent, and therefore useful in diseases of the mucous membranes, &c. An emollient cataplasm is also occasionally prepared from the boiled root. In France, Marsh Mallow is in much greater request than in this country. A favourite preparation there is the Pâte de Guimauve, which is a kind of lozenge made with mucilage of Althæa, gum arabic, sugar, and white of egg. *Althæa rosea*, the Hollyhock of our gardens, has similar properties, and the flowers are on that account officinal in Greece. From the leaves, a blue colouring matter resembling indigo, is obtained. Strong fibres have been also obtained from the bark, and used in the manufacture of good cordage.

Malva sylvestris, the Common Mallow.—This plant has similar properties to the Marsh Mallow. Its bark also yields strong fibres. *Malva Alcea.*—The petals of this plant have astringent properties, and yield a black dye.

Abelmoschus esculentus.—The unripe fruit of this plant, known in the East and West Indies under the names of Ochro, Gombo, Gobbo, Bandikai, &c. is used on account of the abundance of the mucilage it contains, to thicken soups. *Abelmoschus moschatus*, derives its specific name, from the musky odour of its seeds, which are regarded as cordial and stomachic, and are sometimes

mixed with coffee by the Arabians. The powdered seeds steeped in rum are also used in the West Indies as a remedy against the bites of serpents.

Abutilon esculentum.—Bençao de Deos, is another malvaceous plant which furnishes an article of diet, the boiled flowers being used in Brazil as a vegetable.

Malachra capitata.—The leaves are reputed to be anthelmintic, and are employed for that purpose in Panama.

Pavonia diuretica, derives its specific name from its supposed diuretic property, for which purpose it is used in Brazil.

Hibiscus cannabinus, yields the valuable fibre, known under the name of Sunnee or Brown Indian Hemp, which is commonly used in India as a substitute for true Hemp. It is sometimes termed Sunn Hemp, but improperly so, as the true Sunn is obtained from *Crotalaria juncea*, a plant belonging to the Leguminosæ. The seeds of *H. cannabinus* yield a fixed oil. *Hibiscus arboreus*, a native of the West Indies, is also remarkable for the tenacity of its inner bark, and it is said by some authors, that the whips, formerly used by the slave-drivers, were manufactured from its fibres. (See *Lagetta.*) *Hibiscus Rosa-sinensis*, has astringent petals, which are used by the Chinese to blacken their eyebrows, and the leather of their shoes. Various other species of *Hibiscus*, as *H. striatus*, *H. tiliaceus*, &c., also yield valuable fibres, useful for textile fabrics, or for paper-making.

Gossypium.—Several species of this genus furnish cotton, which is the hairy covering of their seeds. (See p. 49.) From the importance of the raw material obtainable from this genus, it must be regarded as one of the most valuable to man in the whole Vegetable Kingdom; indeed it is questionable whether, there is any genus with which he would find it more difficult to do without at the present time, than the genus Gossypium. Several species have been said to yield cotton, but many of these so-called species are probably only varieties. There appear, however, to be three species especially, from which our commercial cotton is obtained, viz.:—1. *Gossypium herbaceum* (or *indicum*), which yields the common cotton of the East Indies. A variety of this furnishes the Chinese or Nankin Cotton, remarkable for its yellowish-brown colour; this colour was formerly thought to be artificial, and produced by dyeing, but it is now known to be natural to it. 2. *G. barbadense* is the species which yields all our best còtton. It is called in India, Bourbon Cotton. From this the much-esteemed Sea Island Cotton is obtained, as also the New Orleans, Georgian, and other cottons derived from the United States. 3. *G. peruvianum* or *acuminatum*, furnishes the South American varieties of cotton, as Pernambuco, Peruvian, Brazilian Cotton, &c. Another species, *Gossypium arboreum*, is the Tree-Cotton of India, and yields a variety of a very fine, soft, and silky nature. This is used by the natives of India for making turbans. The amount of cotton employed for manufacturing purposes in this and other countries has been, and is at the present time, rapidly increasing; hence the cultivation in the East Indies, Africa, &c., of the plants yielding it, is now occupying the serious attention of our Government. This increase in the consumption may be at once judged of by the following statement. In 1800, the amount of cotton imported, was 50,010,732 lbs.; in 1810, it had increased to 132,488,935lbs; in 1820, to 151,672,655 lbs.; in 1830, to 263,961,452 lbs.; in 1840, to 592,488,000lbs.; and in 1850, to about 772,000,000 lbs. This latter amount is equivalent to about 2,000,000 bales, each of which averages 336 lbs. in weight, making altogether about 340,000 tons. It has been computed that, the value of this in a raw state is about 30,000,000*l.*, and when manufactured into cotton fabrics, about three times that amount, or 90,000,000*l.* Of these about 30,000,000*l.* worth were exported from the United Kingdom, and 60,000,000*l.* worth consumed in this country. In the United Kingdom there were at the same period, about 2000 cotton factories, employing a motive power equivalent to that of 90,000 horses, and employing 350,000 human beings. The above interesting statistical record will exhibit in a prominent manner the immense importance of cotton to the inhabitants of this country. Since 1850, the consumption of cotton has enormously increased.

The seeds of the Cotton-plants, after the cotton has been obtained from them, upon being submitted to pressure, yield a fixed oil, which may be used for burning in lamps, and for other purposes. The cake left after the expression of the oil might be used for feeding cattle.

Sida micrantha, and other species, supply fibres useful in the manufacture of cordage, &c. Rocket-sticks are also obtained from the stems of *S. micrantha*.

Sida cordifolia and *S. mauritiana* have demulcent and emollient properties. *S. lanceolata* has a very bitter root, which is reputed to be a valuable stomachic.

Many plants of the order have showy flowers, and are cultivated in our gardens and stoves; for example, the *Althæa rosea*. (Hollyhocks), *Abutilon*, *Hibiscus*, *Sida*, &c. *Hibiscus mutabilis*, is remarkable for the changing colour of its flowers, which vary in a single day from a cream-coloured rose to a rich rose or pink colour.

Natural Order 29. STERCULIACEÆ.—The Silk-Cotton Order. — General Character. — *Trees* or *shrubs*. *Leaves* alternate, simple or compound, with deciduous stipules. *Flowers* usually perfect, sometimes by abortion unisexual, regular or irregular, often surrounded by an involucre. *Calyx* and *corolla* resembling the Malvaceæ, always, however, having five parts; the petals are, moreover, sometimes absent. *Stamens* united by their filaments into a column, or monadelphous, indefinite; *anthers* 2-celled, extrorse. *Carpels* 3 or 5, either distinct, or united so as to form a compound ovary, often stalked; *styles* equal in number to the carpels, distinct or united; *ovules* usually definite, sometimes indefinite. *Fruit* either composed of a number of follicles, or capsular (*fig.* 691), or rarely baccate. *Seeds* with fleshy oily albumen, or none; *embryo* straight or curved; *cotyledons* plicate, or rolled round the plumule.

Diagnosis.—The plants of this order are at once known among the Thalamifloral Exogens, by their valvate 5-parted calyx; contorted corolla consisting of 5 distinct petals; numerous perfect stamens united by their filaments into a column; and 2-celled extrorse anthers. The character presented by the anthers should be particularly noticed, as that alone at once distinguishes them from the Malvaceæ and Byttneriaceæ, which in many other respects they closely resemble. It should also be observed, that the flowers of some of the Sterculiaceæ are unisexual by abortion.

Division of the Order, &c.—This order has been divided into three tribes as follows: —

Tribe 1. *Bombaceæ.*—Leaves palmate or digitate, flowers perfect. *Examples:* — Adansonia, Eriodendron, Bombax, Cheirostemon, Durio, Ochroma.

Tribe 2. *Helictereæ.*—Leaves simple, flowers perfect. *Examples:* — Matisia, Helicteres.

Tribe 3. *Sterculieæ.*—Leaves simple or palmate, flowers unisexual by abortion. *Examples:* — Heritiera, Sterculia, Brachychiton.

Distribution, &c.—Natives of the tropics, or of very warm regions. The *Bombaceæ* are chiefly found in America, the *Sterculieæ* mostly in India and Africa. None of the *Helictereæ* occur in Africa. Lindley enumerates 37 genera, and 128 species as belonging to this order.

Properties and Uses.—In their properties the plants of this order resemble the Malvaceæ, thus, they are generally muci-

laginous, demulcent, and emollient; others have a hairy covering to their seeds, and others yield fibres. The cottony covering of their seeds, and the fibres yielded by plants of this order, are not, however, to be compared in importance to similar products of the Malvaceæ. Some plants are reputed to be diuretic, emetic, or purgative. Many of the *Bombaceæ* are remarkable for their prodigious size, height, and apparently enormous age. The more interesting plants are as follows: —

Adansonia digitata, the Baobab-tree. — The fruit commonly known as Monkey-bread or Ethiopian Sour-gourd, has its seeds surrounded by a large quantity of a starchy pulp, with an acid flavour much resembling cream of tartar. This forms a wholesome and agreeable article of food. When mixed with water it is used as an acid drink, which is regarded as a specific in putrid and pestilential fevers. It is also employed in Egypt in dysentery. All parts of the tree possess emollient and demulcent properties. Its powdered leaves are used by the Africans under the name of Lalo, mixed with their daily food to check excessive perspiration. This property is owing to the presence of an astringent matter, hence they have been found serviceable in diarrhœa, &c. The bark is said to be febrifugal, and its fibres are employed by certain African tribes living where the tree is common, in the manufacture of various articles of dress, cordage, &c. The Baobab-tree is also remarkable for its enormous size, and the great age to which it attains, in some cases reputed to be many thousand years. One tree of this species has been found to have a trunk from 90 to 100 feet in circumference. Their height, however, does not bear the usual proportion to their thickness, as that is generally but little more than their diameter. Their hollowed trunks, are used by the natives in some districts of Africa, as burial-places for such of their dead as are believed to have communion with evil spirits.

Chorisia speciosa has its seeds covered with silky hairs, which are used for stuffing cushions, &c. It is termed Vegetable Silk.

Eriodendron Samauma, a native of South America, is remarkable for its great height. Its trunk frequently overtops all the surrounding trees before it gives off a single branch. The hairy covering of the seeds of various species of *Eriodendron* is employed for stuffing cushions and similar purposes.

Bombax Ceiba, the Silk-Cotton Tree of South America, and *B. pentandrum*, the Silk-Cotton-tree of India, are also remarkable for their size and height. The seeds of these plants are covered by long silky hairs; hence their common names. These hairs cannot be used like those of ordinary cotton for manufacturing purposes, chiefly on account of the smoothness and want of adhesion between their sides. They are used, however, in many parts of the world for stuffing cushions, &c. The bark of *B. pentandrum* is reported to be emetic.

Salmalia.—The bark of some species of this genus is said to be emetic, and honey obtained from the flowers of *S. malabarica* is commonly regarded as both emetic and purgative.

Durio zibethinus.—This tree, which is about the size of the ordinary pear-tree, yields the fruit called Durian, which is highly esteemed in the south-eastern parts of Asia, being accounted next in value to the Mangosteen. It has, however, a strong smell, which renders it disagreeable at first to those unaccustomed to it, but this quality is soon forgotten after the palate has become familiar with it.

Ochroma Lagopus, a West Indian tree, has an antisyphilitic bark, and a spongy wood, which is sometimes used as a substitute for cork.

Cheirostemon platanoides is the Hand-plant of Mexico. It derives its common name from the remarkable appearance of its flowers, the anthers and style of which are so arranged as to resemble a hand furnished with long claws.

Sterculia acuminata.—The seeds of this plant, as well as those of *S. tomentosa*, contain a good deal of mucilage. They constitute the Kola-nuts, which are used in Africa to sweeten water which has become more or less putrid. The seeds of several species of *Sterculia* are eaten in different parts of the globe. This is the case with *S. Chicha*, and *S. lasiantha* in Brazil, and *S. nobilis* in Asia. *Sterculia Tragacantha*, a native of Sierra Leone, receives its specific name from yielding a gum resembling flaky Tragacanth. *S. urens*,

a native of Coromandel, yields a gum of a similar nature, which is called Gum Kutteera. (See also *Cochlospermum Gossypium*, p. 456.) The fruit, seeds, leaves, or bark of other species of *Sterculia*, are also used for various purposes as medicinal agents in different parts of the globe. The seeds of all the species contain a fixed oil, which may be used for burning in lamps, &c. According to Hooker, *S. villosa* and *S. guttata* yield fibres, from which ropes of excellent quality, and cloth are made.

Natural Order 30. BYTTNERIACEÆ.—The Chocolate Order.—General Character.—*Trees, shrubs*, or *undershrubs*, sometimes climbing. *Leaves* simple, alternate, with usually deciduous stipules. *Calyx* 4—5-lobed, valvate. *Corolla* absent, or having as many petals as there are lobes to the calyx, either twisted or induplicate in æstivation, permanent or deciduous. *Stamens* hypogynous, equal in number to the petals and opposite to them, or twice as numerous, or indefinite; when the stamens are more numerous than the petals some are always sterile; *filaments* more or less united; *anthers* 2-celled, introrse. *Ovary* sessile or stalked, composed of 4—10 carpels united round a central column; *style* simple; *stigmas* equal in number to the carpels; *ovules* 2 in each cell. *Fruit* usually capsular with a loculicidal dehiscence, or indehiscent, or the fruit separates into its component parts when ripe—that is, in a septicidal manner. *Embryo* generally lying in a small quantity of fleshy albumen, straight or somewhat curved; *cotyledons* plaited or spiral.

Diagnosis.—The only orders likely to be confounded with this, are the Sterculiaceæ, Malvaceæ, and Tiliaceæ. From the former, it is at once distinguished by its introrse anthers, and by the stamens being definite, or if more numerous than the petals, some of them being always sterile. From the *Malvaceæ*, it is known by its 2-celled anthers, by the stamens being frequently equal in number to the petals and opposite to them, or if more numerous some of them being sterile, and also from the filaments not being united into so evident a column. From the *Tiliaceæ*, it is distinguished readily by its monadelphous stamens, and by the absence of a disk.

Distribution, &c.—They are chiefly tropical plants, but some species of the order are found scattered in almost every quarter of the globe, except Europe. *Examples:*—Lasiopetalum, Abroma, Byttneria, Theobroma, Guazuma, Hermannia, Dombeya, Eriolæna. There are 45 genera, and 400 species.

Properties and Uses.—The plants have properties resembling the Malvaceæ and Sterculiaceæ: thus, some are mucilaginous, as the *Waltheria Douradinha*, the species of *Pterospermums*, the young bark of *Guazuma ulmifolia*, and the bark of *Abroma angustum*, *Dombeya spectabilis*, &c. The fruit of *Guazuma ulmifolia* contains a sweetish, mucilaginous, agreeable pulp, which is eaten in Brazil. By far the most important plant of the order is

Theobroma Cacao, the Cacao or Cocoa Tree.—This tree is a native of Demerara and Mexico, and it is extensively cultivated in the West Indies, &c.

From its seeds, Cacao or Cocoa, and Chocolate are prepared. In the manufacture of Chocolate, the seeds are divested of their husks, roasted, and ground, and afterwards triturated in a mortar with an equal quantity of Sugar, to which is added some Vanilla and Cinnamon for a flavouring, and a small quantity of Arnatto as a colouring agent. All the finer qualities are thus prepared, but the flavouring is sometimes produced by adding Sassafras nuts, or some other aromatics. Chocolate derives its name from the Indian term (*chocolat*). Cocoa or Cacao is, either prepared by grinding up the roasted seeds with their outer shells or husks between hot cylinders into a paste, which is then mixed with starch, sugar, &c.,—this forms *common cocoa*, *rock cocoa*, *soluble cocoa*, &c.,—or the roasted seeds divested of their husks, are broken into small fragments, in which state they form *cocoa nibs*, the purest state of Cocoa. The husks of the Cocoa-seeds are used by the poorer classes of Italy and Ireland in the preparation of a wholesome and agreeable beverage: they are imported from Italy under the name of "miserable." Both Cocoa and Chocolate are used for the preparation of agreeable and nutritious beverages. These beverages are not so stimulating as Tea and Coffee, but they disagree with many persons on account of their oily nature. The generic name, *Theobroma*, was given to this tree by Linnæus, signifying "food of the gods," to mark his opinion of the nutritious and agreeable nature of the beverages prepared from its seeds; but Belzoni, a traveller of the 16th century, regarded them in a very different light, for he declared that Cocoa was a drink "fitter for a pig than for a man."

Cocoa-seeds owe their properties chiefly to a peculiar alkaloid, named *theobromine*, which resembles *theine*, the alkaloid contained in China Tea (see p. 476), &c., and to a fatty or oily matter called *Butter of Cocoa*, which constitutes about half their weight. It has been computed by Johnston, that Cocoa and Chocolate form the common unfermented beverages of about fifty millions of men in Spain, Italy, France, and Central America, and that the consumption of Cocoa annually is about 100,000,000 lbs. Cocoa is also now largely used in Britain; thus in 1852, 6,268,525 lbs. were imported, and of this, about one half was retained for home consumption. From the pulp which surrounds the seeds a peculiar kind of spirit is distilled.

Natural Order 31. TILIACEÆ. — The Lime Tree or Linden Order.—General Character.—*Trees*, *shrubs*, or rarely *herbs*.

Fig. 881.

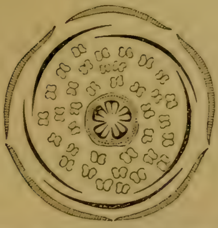


Fig. 882.

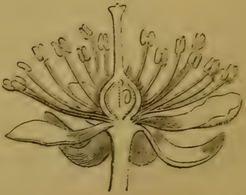


Fig. 881. Diagram of the flower of the Lime.——*Fig.* 882. Vertical section of the flower of the Lime (*Tilia europæa*).

Leaves simple, alternate (*fig.* 267), with deciduous stipules. *Sepals* 4 or 5 (*figs.* 881 and 883), distinct or coherent, valvate in æstivation (*fig.* 883), deciduous. *Petals* equal in number to the sepals (*fig.* 881), or rarely wanting, imbricated. *Stamens* hypogynous, usually numerous (*figs.* 881—883), distinct (*fig.* 883), or polyadelphous (*fig.* 545); *anthers* 2-celled (*figs.* 512 and 881—

Fig. 883.

Fig. 883. Peduncle of the Lime, bearing two flower-buds, and a fully expanded flower.

883), opening longitudinally, or by pores at the apex. *Disk* glandular, hypogynous. *Carpels* 2—10 (*fig.* 881), which are generally united so as to form a compound many-celled ovary, sometimes disunited; *placentas* axile (*fig.* 881); *style* 1 (*figs.* 882 and 883); *stigmas* equal in number to the carpels. *Fruit* dry or pulpy, sometimes samaroid, usually many-celled, or rarely 1-celled by abortion. *Seeds* solitary or numerous; *embryo* erect, straight, in the axis of fleshy albumen; *cotyledons* flat and leafy (*fig.* 741 *c.*); *radicle* next the hilum.

Diagnosis. — This order resembles in many respects, the Malvaceæ, Sterculiaceæ, and Byttneriaceæ. It may be at once distinguished from them, by having a glandular disk, by the stamens not being monadelphous, and by the anthers being 2-celled. From all other Thalamifloral Exogens the plants of this order may be known by their alternate, entire, stipulate leaves; valvate æstivation of calyx, which is also deciduous; floral envelopes in 4 or 5 divisions; stamens hypogynous, either distinct or polyadelphous; anthers 2-celled; hypogynous glandular disk; many-celled fruit with axile placentas; and embryo erect, straight, in the axis of fleshy albumen.

Divisions of the Order, &c. — The order has been divided into two tribes as follows: —

Tribe 1. *Tilieæ.* — Corolla with entire petals, or wanting; anthers dehiscing longitudinally. *Examples:* — Lühea, Corchorus, Triumfetta, Tilia, Grewia, Aristotelia.

Tribe 2. *Elæocarpeæ.* — Petals lacerated, anthers opening at the apex. *Examples:* — Elæocarpus, Monocera, Vallea.

Distribution, &c.—A few are found in the northern parts of the world, where they form large trees, but the plants of the order are chiefly tropical, and occur in such parts, as herbs, shrubs, or trees. There are 38 genera, and 350 species.

Properties and Uses.—In their properties, the Tiliaceæ resemble the Malvaceæ. They are altogether innocuous, and are generally mucilaginous, emollient, and demulcent. Many of them also yield fibres, which are much used for manufacturing

purposes Some are valuable timber-trees, and some have edible fruits. A few of the more important plants may be mentioned as follows:—

Lühea grandiflora.—The bark is astringent, and is employed in Brazil for tanning leather. The wood of other species is used for various purposes in Brazil, as for making soles to boots, musket-stocks, &c.

Corchorus capsularis, the Jute Plant. — The fibres obtained from the bark of this plant, are commonly known under the name of Jute or Jute-hemp. This fibre is of a very valuable nature, and is now imported in enormous quantities into this country, where it is used chiefly in the manufacture of coarse bags, and as a foundation for inferior carpets, &c. It is also frequently mixed with silk in the manufacture of cheap satin fabrics. It does not appear to be well adapted for cordage, because it will not bear exposure to wet. In India it is used chiefly for the purpose of making coarse canvass, called *Gunny*, which is the material employed there for bags, &c., which are employed for packing raw produce. *Corchorus olitorius*, commonly called Jews' Mallow, is used in some parts of the world as a pot-herb. In Panama, the leaves of *C. mompoxensis* are infused in boiling water, and the infusion is then taken as a substitute for tea.

Triumfetta.—Several species of this genus have astringent and mucilaginous leaves and fruits, and are employed in Brazil for making injections, which are reputed to be useful in gonorrhœa.

Tilia europæa, Common Lime or Linden Tree. —The inner bark is used in the northern parts of Europe, more particularly in Russia, in the manufacture of mats, which are commonly known as Russian, Bast, or Bass-mats. This Bast is one of the substances employed by gardeners for tying up plants. The flowers are very fragrant when fresh, and an infusion of them is much used on the Continent for its expectorant and antispasmodic properties. The wood of this and other species of *Tilia* is very white and smooth, and is employed for various purposes, as for carving, wainscoting, &c.

Grewia sapida. asiatica, &c., have pleasant acid fruits, and are used in the East for making Sherbet. *Grewia elastica* affords valuable timber.

Aristotelia Maqui has an edible fruit, and from it a kind of wine has been also made. The fibres of the bark and the wood, have been used in the manufacture of musical instruments.

Elæocarpus serratus.—The fruit of this plant is commonly known under the name of Molucca Berries. When divested of its pulp, the endocarp, which is hard and bony, and beautifully furrowed, is used for making necklaces. These are frequently brought as presents from India, and are also occasionally sold in this country. The fruits of some species are eaten, while others are used in the preparation of Indian curries.

Vallea cordifolia.—The leaves are employed for the purpose of dyeing yellow.

Natural Order 32. DIPTERACEÆ.—The Sumatra-Camphor Order.—General Character.—Large *trees* with resinous juice. *Leaves* alternate, involute, feather-veined, with large convolute deciduous stipules. *Calyx* 5-lobed, tubular, unequal, persistent imbricated, ultimately enlarged into wing-like expansions. *Petals* 5, hypogynous, often coherent at the base ; *æstivation* twisted. *Stamens* numerous, hypogynous, distinct, or united in an irregular manner by their filaments so as to become somewhat polyadelphous; *anthers* innate, 2-celled, subulate, prolonged above or beaked. *Ovary* superior, 3-celled, *ovules* pendulous; *style* and *stigma* simple. *Fruit* 1-celled, dehiscent or indehiscent, surrounded by the enlarged permanent calyx. *Seed* solitary, exalbuminous ; *radicle* superior.

Diagnosis.—Large trees with simple alternate involute leaves, and large deciduous convolute stipules. Flowers perfect and symmetrical. Calyx and corolla each with five divisions; the former, unequal, permanent, imbricated in æstivation, and ulti-

mately enlarged so as to form wing-like expansions crowning the fruit; the latter with equal petals, and twisted in æstivation. Stamens hypogynous, numerous, with beaked anthers. Fruit 1-celled, 1-seeded. Seed without albumen; radicle superior.

Distribution, &c.—Natives exclusively of the forests of the tropical East Indies, with the exception of the genus *Lophira*, which belongs to tropical Africa. The latter genus, by Endlicher and others, has been separated from the Dipteraceæ, and placed in an order by itself under the name of Lophiraceæ. The chief characters of distinction are, its 1-celled ovary with numerous ovules on a free central placenta, and its inferior radicle. *Examples:*— Dipterocarpus, Dryobalanops, Vateria, Shorea. There are 8 genera (or 7, if we exclude *Lophira*), and 48 species.

Properties and Uses.—The plants of this order form very large and handsome trees, which abound in an oleo-resinous juice. To the presence of this they owe their peculiar properties. The more important plants are as follows:—

Dipterocarpus.—Several species of this genus, as *D. turbinatus*, *D. costatus*, *D. alatus*, and *D. incanus*, yield an oleo-resinous substance, called Wood-oil, or Gurjun Balsam. In its properties it resembles the so-called Balsam of Copaiba, and is used for similar purposes, and has been even sold in England for that drug. Wood-oil is also used in India for painting houses, &c.

Dryobalanops aromatica or *Camphora.*—This is a large tree, a native of Sumatra and Borneo. From its stem a liquid, called Liquid Camphor or Camphor-oil, and a crystalline solid substance, which is named Sumatra or Borneo Camphor are obtained. The *Liquid Camphor* is obtained by making deep incisions into the tree. It is a hydro-carbon, and has an odour resembling a mixture of Cajeput-oil, camphor, and cardamoms. It has been used in the preparation of scented soap. The *Solid Sumatra Camphor* is found in fissures and cavities in the interior of the trunk, and can only be extracted from the tree by cutting it down and dividing it into pieces. It generally occurs only in small pieces, but occasionally, masses weighing 10 or 12 lbs. have been removed. This camphor resembles in its properties the ordinary officinal or Laurel Camphor. It is not, however, a commercial article in this country, or in Europe, because it is so highly esteemed by the Chinese, that they will give from 80 to 100 times more money for it than that which they obtain for their own camphor, which is the kind used in this country, and which is believed by us to be equally beneficial. The solid camphor can only be obtained from the mature trees, while the liquid oil is obtainable also from the young; hence it is probable that, the liquid oil becomes converted into the solid camphor as the trees increase in age.

Vateria indica.—This plant yields an oleo-resinous substance, which is known in India under the name of Piney Resin, or Piney Dammar. It is used as a varnish, and for making candles. It has been imported in small quantities into this country under the name of Piney Tallow. It has some resemblance to Indian Copal or Gum Anime, and has been sometimes confounded with that substance, which is supposed to be the produce of *Hymenæa Courbaril*, a plant belonging to the Leguminosæ. (See *Hymenæa.*)

Shorea robusta is a valuable timber-tree; it is a native of India, and its wood is there extensively used under the name of Sál. A balsamic resin is also obtained from the plant called Ral, Dhoona, or Dammar-pitch, which is principally employed for incense. *S. Tumbugaia* yields a similar resin in India.

Natural Order 33. Chlænaceæ.—The Sarcolæna Order.—General Character.—*Trees* or *shrubs*. *Leaves* entire, alternate, with large deciduous convolute stipules. *Flowers* regular,

unsymmetrical, furnished with an involucre; the *involucre* surrounding 1—2 flowers, and persistent. *Sepals* 3, imbricated. *Petals* 5, convolute, sometimes coherent at the base. *Stamens* generally very numerous, rarely but 10, monadelphous; *anthers* roundish, 2-celled. *Ovary* 3-celled; *style* 1; *stigma* trifid. *Fruit* capsular, 3-celled, or rarely 1-celled; *placentas* axile. *Seeds* solitary or numerous, suspended; *embryo* in the axis of fleshy albumen; *cotyledons* leafy; *radicle* superior.

Diagnosis.—Readily distinguished among Thalamifloral Exogens, by their alternate, simple, stipulate leaves; and involucrate flowers, which are regular and unsymmetrical,—that is, with 3 sepals, 5 petals, stamens frequently some multiple of five, and 3 carpels to the ovary. The calyx is also imbricated, the stamens monadephous, and the seed has abundant albumen.

Distribution, &c.—There are but 4 genera, and 8 species included in this order, all of which are natives of Madagascar. *Examples:*—Sarcolæna, Leptolæna, Schizolæna, Rhodolæna.

Properties and Uses.—Altogether unknown.

Natural Order 34. TERNSTRŒMIACEÆ OR CAMELLIACEÆ.—The Tea or Camellia Order.—General Character.—*Trees* or *shrubs. Leaves* leathery, alternate, usually exstipulate, and sometimes dotted. *Flowers* regular, and generally very showy, rarely polygamous. *Sepals* 5 or 7, coriaceous, imbricated, deciduous. *Petals* 5, 6, or 9, often coherent at the base, imbricated. *Stamens* hypogynous, numerous, distinct, or united by their filaments into one or several bundles; *anthers* 2-celled, versatile, or adnate. *Ovary* superior, many-celled; *styles* filiform, 3—7; *Fruit* capsular, 2—7-celled; *placentas* axile; dehiscence various. *Seeds* few, sometimes arillate; *albumen* wanting, or in very small quantity; *embryo* straight or folded; *cotyledons* large and oily; *radicle* towards the hilum.

Diagnosis.—Trees or shrubs, with alternate usually exstipulate leaves. Sepals and petals imbricated in æstivation, and having no tendency to a quaternary arrangement. Stamens numerous, hypogynous; anthers versatile, or adnate. Ovary superior; styles filiform. Seeds solitary, or very few, attached to axile placentas; albumen wanting, or in very small quantity.

Distribution, &c.—The plants of this order, which are mostly ornamental trees or shrubs, are chiefly natives of South America, but a few are found in the East Indies, China, and North America. One only occurs in Africa. There are no European species, although a few are cultivated in Europe; these are principally from China and North America. *Examples:*—Ternstrœmia, Cleyera, Freziera, Stuartia, Gordonia, Camellia, Thea. The order, as defined by Lindley, contains 37 genera, and about 130 species.

Properties and Uses.—Generally speaking, we know but little of the properties of the plants of this order; but some, as those

from which China Tea is prepared, are moderately stimulant and astringent, slightly soothing and sedative, and indirectly nutritive.

The following are the more important plants belonging to the order: —

Freziera theoides.—The leaves of this shrub are used as a kind of tea in Panama.

Kielmeyera speciosa.—The leaves of this plant, which is a native of Brazil, contain much mucilage, and are employed on that account for fomentations.

Gordonia.—The bark is astringent and is therefore useful in tanning, for which it is sometimes used in the United States.

Camellia japonica.—Numerious varieties of this species, which is a large tree in its native country, are cultivated in our greenhouses, and are celebrated for the beauty of their flowers and foliage. The seeds of *C. oleifera* yield by expression a good salad-oil. *C. Sasanqua* has fragrant flowers, which are said to be used in some districts to give flavour and odour to Chinese Tea.

Thea.—From the leaves of two or more species or varieties of this genus, the tea which is so extensively used in this and some other countries is prepared. Two species are natives of China, namely, *Thea Bohea* and *T. viridis*, from which China Tea is obtained. Another species, *Thea assamica*, furnishes Assam Tea. There is considerable doubt, however, whether these should be considered as distinct species, or only as varieties of one, owing their differences to soil, climate, mode of cultivation, &c. It was formerly supposed, that Black Teas could only be obtained from *T. Bohea*. and Green Teas from *T. viridis*, but Mr. Fortune and others have proved, that both Black and Green Teas may be made indifferently from either *T. Bohea* or *T. viridis*, the differences between such teas depending, partly, on the species or variety of plant from which the leaves have been obtained, but more particularly from the time of gathering, and mode of preparation. Thus, Green Teas, are generally prepared by drying the young leaves as quickly as possible after they are gathered; then slightly heating them, after which they are rolled separately or in small heaps, and then dried as quickly as possible: while Black Teas are usually made from the older leaves, which, after being gathered, are exposed to the air for some time; and then, after having been tossed about, are placed in heaps, where they undergo a kind of fermentation; after which they are exposed to a fire for a short time; then rolled in masses to get rid of the moisture, and to give them a twisted character; after which they are again exposed to the air, and finally dried slowly over a fire. Thus, Green Tea consists of the young leaves quickly dried after gathering, so that their colour, &c., is preserved, and Black Tea is the older leaves dried some time after being gathered, and after they have undergone a kind of fermentation, by which their original green colour is changed to black, as well as other important changes produced. Several varieties of Black and Green Teas are known in commerce. Thus of the former, we have Bohea, Congou, Souchong, Pekoe, Caper, &c.; of the latter, Hyson, Hyson-Skin, Twankay, Imperial, Gunpowder, &c. The finer varieties of tea, are prepared from *T. viridis*. Some teas have a particular odour, somewhat resembling the flowers of the common Cowslip; this is produced by mixing with them the dried flowers of the sweet-scented olive (*Olea fragrans*). Other teas are scented with the dried flowers of *Chloranthus inconspicuus*, *Aglaia odorata*, &c.

The cultivation of the Tea-plant is now being carried on with success by the East-Indian Government in certain districts of the Himalayas. A large quantity of Black Tea is also now obtained from Assam. China, however, is the great tea-producing country; in that part of the world, 3,500,0 0 acres of ground are devoted to it alone, and the total produce in 1852, according to Johnston, was 1,000,000 tons, or 2,240 millions of pounds. In the United Kingdom, the consumption of Tea annually is nearly 60,000 millions of pounds, or about 26,000 tons, being at the rate of about 2 lbs. per head of the population. Tea owes its chief properties to the presence of a volatile oil, tannin, and an alkaloid called *theine;* which is identical with *caffeine*, the alkaloid contained in Coffee, and *guaranine*, the alkaloid of Guarana (see p. 483); and closely allied to *theobromine*, the alkaloid of cocoa seeds (see p. 471). Tea-leaves also contain about 6 per cent of gluten, but this is scarcely extracted in any amount by the ordinary mode of making Tea. It has been recently proved that Tea, besides its stimulating and soothing effects, is indirectly nutritive, — that is to say, the theine it contains has the effect of pre-

venting the waste and decay of the body, and any substance that does this necessarily saves food, and is thus indirectly nutritive.

Natural Order 35. GUTTIFERÆ OR CLUSIACEÆ. — The Gamboge or Mangosteen Order. — General Character. — *Trees* or *shrubs*, sometimes parasitical, with a resinous juice. *Leaves* coriaceous, entire, simple, opposite (*fig.* 884), exstipulate. *Flowers* usually perfect, sometimes unisexual by abortion. *Sepals* 2, 4, 5, 6, or 8, imbricated, usually persistent, frequently unequal and petaloid. *Petals* hypogynous, equal in number to (*fig.* 884), or a multiple of the sepals, sometimes passing by imperceptible gradations into them. *Stamens* usually numerous, rarely few, hypogynous, distinct, or monadelphous, or polyadelphous; *anthers* adnate, not beaked, introrse or extrorse, opening by a pore or transverse slit, 2-celled, or sometimes 1-celled. *Disk* fleshy, or rarely with 5 lobes. *Ovary* superior (*fig.* 884), 1 or many-celled; *style* absent; *stigmas* peltate or radiate (*fig.* 884); *placentas* axile. *Fruit* dehiscent or indehiscent, dry or fleshy, 1 or many-celled. *Seeds* solitary or numerous, frequently arillate, without albumen; *embryo* straight.

Fig. 884.

Fig. 884. Flowering stem and fruit of the Mangosteen Plant (*Garcinia Mangostana*).

Diagnosis. — Trees or shrubs with a resinous juice, and opposite, simple, coriaceous, exstipulate leaves. Sepals and petals usually having a binary arrangement of their parts; the former imbricated and frequently unequal; the latter equal and hypogynous. Stamens almost always numerous; anthers adnate, without a beak, opening by a pore, or transversely. Disk fleshy, or lobed. Ovary superior, with sessile radiant stigmas, and axile placentas. Seeds exalbuminous.

Distribution, &c. — Exclusively tropical, and especially occurring in moist situations. The larger proportion of the plants of the order are natives of South America, but a few occur in Madagascar and the African continent. *Examples:* — Clusia, Mammea, Garcinia, Xanthochymus, Cambogia, Calophyllum. There are 32 genera, and 150 species.

Properties and Uses. — The plants of this order are chiefly remarkable for yielding a yellow gum-resin of an acrid and purgative nature. In many cases, however, the fruits are edible, and are held in high estimation for their delicious flavour. The seeds of some are oily, and some are good timber-trees. The more important plants are as follows: —

Clusia flava.—This species, as well as *C. alba* and *C. rosea*, yield a glutinous resinous matter, which is used in some parts of the West Indies in place of pitch. *C. flava* is called in Jamaica the Balsam-tree. In Nevis and St. Kitt's the three species are known indifferently under the names of Fat Pork, Monkey Apple, and Mountain or Wild Mango. The flowers of *C. insignis* also yield a resinous substance in Brazil.

Mammea americana.—The fruit of this plant is highly esteemed in the West Indies and South America. It is known under the names of the Mammee Apple and Wild Apricot of South America. The seeds are anthelmintic. A spirit and a kind of wine may be also obtained from this plant,—thus, from the flowers a kind of spirit, and from the sap a wine.

Garcinia.—One or more species of this genus are supposed to yield our commercial and officinal Gamboge, which comes from Siam. It was at one time thought that it was obtained from *G. cochin-chinensis*, but the investigations of Dr. Christison have led to the belief, that the species yielding it is nearly allied to *G. elliptica;* but at present that plant has not been described. Two kinds of Gamboge are known to pharmacologists, viz., Siam and Ceylon, which are so named from the countries in which they are respectively produced. The Siam is the finest and only commercial kind in Europe. It occurs in two forms :—1st. In the form of cylinders, which are either solid or hollow, and commonly named *pipe* or *roll Gamboge*. 2nd. In large cakes or amorphous masses, called *lump* or *cake Gamboge*. The pipe Gamboge is the finest kind. Gamboge is used in medicine as an active hydragogue and drastic purgative. It is also an anthelmintic. In over-doses it acts as an acrid poison. Gamboge also forms a valuable water-colour, and hence is much used in painting ; it is also employed to give a colour to the lacquer-varnish for brass-work, &c. *G. elliptica*, a native of Silhet and Tavoy, also yields a kind of Gamboge, and *G. pictoria* is supposed to produce a kind called *Coorg* or *Wynaad Gamboge*. These kinds are unknown in commerce, as well as the Ceylon kind already mentioned. This latter is obtained from *Hebradendron cambogioides* of Graham. Ceylon Gamboge is used in India both as a medicine and as a pigment, but it is inferior to Siam Gamboge in both those particulars. Its inferiority may probably arise from want of care in its preparation.

The Mangosteen, which is reputed to be the most delicious of all fruits, is obtained from *G. Mangostana* (*Fig.* 884), a native of Malacca This plant has recently produced fruit in stoves in this country. The rind is astringent. *G. cornea*, *Kydiana*, and *pedunculata*, also yield fruits of a similar character to the Mangosteen, although very inferior to it. The seeds of *G. purpurea*, upon being boiled in water, yield a concrete oil, called Kokum Butter, or Concrete Oil of Mangosteen. It is useful in chapped hands, &c. A good deal has been recently imported into this country.

Mesua.—The species of this genus are remarkable for their very hard timber. Lindley remarks, "that the root and bark of these plants are bitter, aromatic, and powerfully sudorific ; their leaves mucilaginous ; their unripe fruit aromatic, acrid, and purgative." The flower-buds of *Mesua ferrea*, occur in the bazaars of India under the name of Nag-kassar ; they are highly esteemed for their fragrance, and are also used in Bengal, as well as the leaves of the same plant, as antidotes to snake-poisons. Nag-kassar was imported into England a few years since. The flower-buds are about the size of pepper-corns, of a cinnamon-brown colour, and have a very fragrant odour somewhat resembling that of violets. Nag-kassar would be probably useful in perfumery.

Calophyllum Calabra.—This is said to yield the resinous substance known as East Indian Tacamahaca. It has a fragrant odour. *C. inophyllum* and *C. braziliense* also yield similar resins. From the seeds of the former also, an oil may be obtained. *C. angustifolium*, the Piney-tree, furnishes valuable timber.

Pentadesma butyracea.—The fruit of this plant, when cut, yields a fatty matter ; hence it is called the Butter or Tallow Tree of Sierra Leone.

Natural Order 36. HYPERICACEÆ. — The St. John's Wort Order (*figs.* 885—887). – General Character.—*Herbs*, *shrubs*, or *trees*. *Leaves* opposite or rarely alternate, exstipulate, simple, often dotted, and bordered with black glands. *Flowers* regular. *Sepals* 4 or 5 (*fig.* 885), persistent, unequal, distinct or united at the base, imbricated. *Petals* (*fig.* 885) equal in

Fig. 885.

Fig. 886.

Fig. 887.

Fig. 885. Diagram of the flower of a species of St. John's Wort (*Hypericum*).——*Fig.* 886. Vertical section of the flower of a species of *Hypericum*.——*Fig.* 887. Vertical section of the seed of a species of *Hypericum*.

number to the sepals, hypogynous, unequal-sided, frequently bordered with black glands; *æstivation* twisted. *Stamens* usually numerous, rarely few, hypogynous (*fig.* 886), mostly polyadelphous (*fig.* 542), or rarely distinct, or monadelphous, sometimes having fleshy glands alternating with the bundles of stamens; *filaments* filiform; *anthers* 2-celled, with longitudinal dehiscence. *Ovary* 1-celled, formed of from 3—5 carpels, which are partially inflected so as to project into the cavity; or 3—5-celled by the union of the dissepiments in the centre (*fig.* 885); *styles* equal in number to the carpels; *stigmas* usually capitate or truncate, rarely 2-lobed. *Fruit* capsular, usually 3—5-celled, sometimes 1-celled; *placentas* axile or parietal, dehiscence septicidal. *Seeds* minute, numerous; *embryo* straight or curved, exalbuminous (*fig.* 887).

Diagnosis. — Leaves usually opposite, simple, exstipulate. Flowers regular. Sepals and petals hypogynous, with a quaternary or quinary distribution; the former with an imbricated æstivation; the latter unequal-sided, commonly marked with black glands, and having a contorted æstivation. Stamens hypogynous, usually numerous and polyadelphous, rarely few, and then distinct or monadelphous; anthers 2-celled, opening longitudinally. Styles several, long. Fruit 1-celled, or 3—5-celled. Seeds numerous, naked, exalbuminous.

Distribution, &c. — The plants are generally distributed over the globe, inhabiting both temperate and hot regions, and almost all varieties of soil. *Examples*: — Ascyrum, Hypericum, Vismia. There are 16 genera, and 276 species.

Properties and Uses. — They abound generally in a resinous yellow juice, which is frequently purgative; as in *Vismia guianensis*, *micrantha*, &c. Other plants of the order, as *Hypericum perforatum*, *Androsæmum officinale*, &c., have tonic

and astringent properties, and *Cratoxylon Hornschuchia* is slightly astringent and diuretic.

Natural Order 37. Reaumuriaceæ.—The Reaumuria Order.—This small order was first instituted by Ehrenberg. The plants belonging to it do not differ in any essential characters from Hypericaceæ, except that they have a pair of appendages at the bases of the petals, and shaggy seeds with a small quantity of mealy albumen.

Distribution, &c.—Natives of the coast of the Mediterranean and the salt plains of Northern Asia. *Examples :*—Hololachna, Reaumuria, Eichwaldia. There are 3 genera, and 4 species.

Properties and Uses.—The plants contain much saline matter. A decoction of the leaves of *Reaumuria vermiculata* is used internally, and the bruised leaves as an external application, for the cure of scabies.

Natural Order 38. Marcgraviaceæ.—The Marcgravia Order.—This is a small order of plants which is generally regarded as being allied to Clusiaceæ and Hypericaceæ. The species belonging to it are chiefly distinguished from Clusiaceæ, by their alternate leaves, unsymmetrical flowers, versatile anthers, and very numerous minute seeds. Some genera of the order are remarkable for their peculiar bracts, which become hooded, pouched, or spurred. They are distinguished from Hypericaceæ, chiefly by their alternate leaves, unsymmetrical flowers, equal-sided petals, distinct stamens, and sessile stigmas.

Distribution, &c.—Generally natives of equinoctial America. *Examples :*—Ruyschia, Norantea, Marcgravia. There are 4 genera, and 26 species.

Properties and Uses.—Scarcely anything is known of their properties. *Marcgravia umbellata* is reputed to be diuretic and antisyphilitic. The order is chiefly interesting for the curious pitcher-like bracts which some of their genera exhibit.

Natural Order 39. Rhizobolaceæ.—The Souari-nut Order.—General Character.—Large *trees*. *Leaves* opposite, coriaceous, digitate, exstipulate, with an articulated stalk. *Sepals* 5 or 6, more or less coherent, imbricated. *Petals* 5 to 8, unequal. *Stamens* very numerous, slightly monadelphous, in two whorls, the inner shorter and often abortive, inserted with the petals on a hypogynous disk; *anthers* 2-celled with longitudinal dehiscence. *Ovary* 4, 5, or many-celled; *styles* short, as many as the cells of the ovary; *stigmas* small; *ovules* solitary, attached to the axis. *Fruit* consisting of several combined, indehiscent, 1-seeded nuts. *Seed* reniform, exalbuminous, with the funiculus expanded so as to form a spongy excrescence; *radicle* very large, forming nearly the whole of the nucleus; *cotyledons* very small (*fig.* 749).

Diagnosis.—Large trees, with opposite, digitate, exstipulate leaves, with an articulated stalk. Flowers regular, hypogynous.

Petals equal-sided, and inserted with the numerous stamens into a hypogynous disk. Styles very short. Seed solitary, exalbuminous, with a very large radicle, and two small cotyledons.

Distribution, &c.—The order contains but 2 genera, including 8 species, all of which are large trees, natives of the forests in the hottest parts of South America. *Examples:*—Caryocar, Anthodiscus.

Properties and Uses.—Some of the trees are valuable for their timber. Others yield edible nuts, and some an excellent oil. The most important plant is the

Caryocar butyrosum (*Pekea tuberculosa* or *butyrosa*); this is much esteemed for its timber, which is used in ship-building and for other purposes. The separated portions of the fruit constitute the Souari, Surahwa, or Suwarrow-nuts of commerce, the kernels of which are probably the most agreeable of all the nut kind. They are occasionally imported into this country. An excellent oil (it is said, not inferior to Olive), may be also extracted from them.

Natural Order 40. SAPINDACEÆ.—The Soapwort Order.—General Character (*figs.* 888—890).—Usually large *trees* or twining *shrubs*, or rarely climbing *herbs*. *Leaves* generally

Fig. 888. *Fig.* 889. *Fig.* 890.

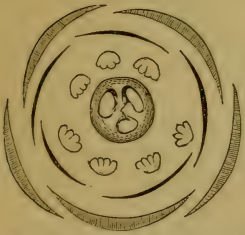


Fig. 888. Diagram of the flower of the Horse-chestnut (*Æsculus Hippocastanum*).——*Fig.* 889. Vertical section of the flower of the Horse-chestnut.——*Fig.* 890. Vertical section of the seed of the Horse-chestnut.

compound (*Fig.* 345), rarely simple, alternate or sometimes opposite, often dotted, stipulate or exstipulate. *Flowers* (*Figs.* 888 and 889), mostly perfect and unsymmetrical, sometimes polygamous. *Sepals* 4—5, (*Fig.* 888), either distinct, or coherent at base, imbricated. *Petals* 4—5, rarely 0, hypogynous, alternate with the sepals, imbricated, (*Fig.* 888), naked, or furnished with an appendage on the inside. *Stamens* 8—10, rarely 5—6—7 (*Fig.* 888), or very rarely 20, inserted into the disk, or into the thalamus; *filaments* distinct or slightly monadelphous; *anthers* introrse, bursting longitudinally. *Disk* fleshy or glandular. *Ovary* usually 3-celled (*Fig.* 888), rarely 2 or 4-celled, each cell containing 1, 2 (*Fig.* 714), 3, or rarely more ovules; *style* undivided, or 2—3 cleft. *Fruit* either fleshy and indehiscent;

or capsular, or samaroid, with 2—3 valves. *Seeds* (*Fig.* 890), usually arillate, exalbuminous; *embryo* rarely straight, usually curved (*fig.* 890), or twisted in a spiral direction; *cotyledons* sometimes very large; *radicle* next the hilum.

Diagnosis. — Flowers unsymmetrical, hypogynous. Sepals and petals 4—5, imbricated, the latter commonly with an appendage. Stamens never agreeing in number with the sepals and petals, and inserted on a fleshy or glandular disk, or upon the thalamus; anthers bursting longitudinally. Fruit usually consisting of 3 carpels. Seeds commonly 2, sometimes 1 or 3, or very rarely more, exalbuminous, usually arillate and without wings; embryo almost always curved or spirally twisted.

Division of the Order, &c. — This order is divided into 4 sub-orders, as follows: —

Sub-order 1. *Sapindeæ.* Leaves alternate. Ovules usually solitary. Embryo generally curved, or sometimes straight. *Examples:* — Paullinia, Sapindus, Nephelium.

Sub-order 2. *Hippocastaneæ.*—Leaves opposite. Ovules 2 in a cell, of which one is ascending, and the others suspended, (*Fig.* 714). Embryo curved (*Fig.* 890), with a small radicle and large fleshy consolidated cotyledons. *Examples:* — Æsculus, Pavia.

Sub-order 3. *Dodoneæ.*—Leaves alternate. Ovules 2 or 3 in a cell. Embryo spiral. *Examples:* — Kœlreuteria, Dodonæa, Ophiocaryon.

Sub-order 4. *Meliosmeæ.* — Leaves alternate. Flowers very irregular. Stamens 5, 3 of which are abortive, and only 2 therefore, fertile. Ovules 2 in a cell, both of which are suspended. Fruit a drupe. Embryo folded up. *Example:* — Meliosma.

Distribution, &c. — Chiefly found in tropical regions, especially those of South America and India; some occur in temperate climates, but none inhabit the cold northern parts of the globe. There are no native plants of this order in Europe. The Horse-chestnut, now so well known in Europe, is only naturalised amongst us. There are about 73 genera, and 400 species.

Properties and Uses. — One of the most prominent properties of the order is the presence of a saponaceous principle, from which its name is derived. Many are poisonous in all their parts; but it is more frequently the case that, while the root, leaves, and branches are dangerous, the poisonous juice becomes so diffused throughout their succulent fruits as to render them innocuous, or in other cases, even valuable articles of dessert. It sometimes even happens that while the pericarp is wholesome, the seeds are dangerous. Some plants of the order are astringent and aromatic; others are diaphoretic, diuretic, and

aperient; and some are valuable timber-trees. A few of the more important plants are the following : —

Cardiospermum Halicacabum.— The root is described as diuretic, diaphoretic, and aperient. Its leaves when boiled, are eaten as a vegetable in the Moluccas.

Paullinia sorbilis. Guarana, or Brazilian Cocoa.— The seeds of this plant are used in Brazil in the preparation of a kind of food, and in the cure of many diseases. The food is known as Guarana bread, and is prepared by taking the dried seeds deprived of their aril, and pounding and kneading them into a mass, which is afterwards made into oblong or rounded cakes. These cakes are used in the same manner as we use cocoa and chocolate,—that is, they are mixed with water, and the mixture sweetened and drank. This beverage is largely consumed in Brazil, both on account of its nutritive qualities, and for its stomachic, febrifugal, and aphrodisiac effects. It contains a bitter crystalline principle called Guaranine, which appears to be identical with *theine* and *caffeine* (see p. 476), the active principles of tea and coffee, and hence, Guarana bread has a similar effect upon the system to that produced by those two beverages. (See *Tea* and *Coffee*.) In many species of *Paullinia*, the narcotic property, which is but slightly evident in *P. sorbilis*, is very evident. Thus, the leaves, bark, and fruit of *P. pinnata* are very dangerous, and are used in the preparation of a poison by the Brazilians, which slowly but surely destroys life. Martius suggests, that this poison might be efficacious in hydrophobia and insanity. *P. cururu* and *P. australis* have similar poisonous properties.

Sapindus Saponaria.—The fruits of this species, as well as those of *S. inæqualis* and others, contain a saponaceous principle, so that when mixed with water, they form an abundant lather ; hence they are used in the West Indies instead of soap. It is said, that " a few of them will cleanse more linen than sixty times their weight of soap." These plants also contain a narcotico-acrid principle, as the pounded fruits when thrown into water in which fish are contained, will produce upon them a kind of intoxication. The pericarp of *S. senegalensis*, is eaten, but the seeds act as a narcotico-acrid poison. The fruit of *Sapindus esculentus* and others are also edible.

Schmidelia serrata has an astringent root, which has been used in India for diarrhœa.

Cupania (*Blighia*) *sapida.*—The distilled water of the flowers is used by negro-women as a cosmetic. The succulent, slightly acid arillus of the seeds is eaten, and much esteemed in the West Indies and elsewhere. The fruit in which the seeds are contained is commonly known under the name of the Akee-fruit. A decoction of these has been used in diarrhœa.

Nephelium (*Euphoria*).—This genus yields the delicious fruits of China and the Indian Archipelago, known under the names of Litchi, Longan, and Rambutan. *Nephelium Litchi* produces the Litchi; *N. Longan*, the Longan ; and *Nephelium Rambutan*, the Rambutan-fruit. A few of the Litchi fruits are occasionally imported. It should be noticed, that the seeds of all these fruits are very bitter, and are probably poisonous.

Æsculus Hippocastanum. The Horse-chestnut.—The bark is febrifugal. Its young leaves are somewhat aromatic, and Endlicher says that they have been used as a substitute for Hops. The seeds have been long employed as an excellent food for sheep in Switzerland, and have been also recommended as a substitute for Coffee. They also contain a saponaceous principle like the fruits of certain species of *Sapindus*, already noticed. They contain, moreover, a large quantity of starch, and they are now much used in France, instead of potatoes and cereals, for the production of that substance. This must be regarded as a most important application of a seed hitherto generally considered in most parts of Europe as useless, as by its employment in the manufacture of starch, a large amount of food will be rendered available from potatoes and cereals, which was formerly lost to man &c., to the extent in which these substances were used for that purpose. The roots, leaves, and fruits of the *Æsculus ohiotensis*, the Buck-eye or American Horse-chestnut, are generally regarded as poisonous, both to man and animals.

Dodonæa.—Some of the species of this genus are aromatic. The wood of *D. dioica* is carminative. Others are reputed slightly purgative and febrifugal.

Ophiocaryon paradoxum. The Snake-nut Tree of Demerara.—This is so

called, from the large embryo of its seed resembling in a remarkable degree a coiled-up snake.

The fruit of many plants belonging to this order, besides those already named, are edible, as that of *Pierardia sativa* and *dulcis*, producing the Rambeh and Choopa of Malacca; and *Hedycarpus malayanus* producing the Tampui. *Schmidelia edulis*, in Brazil; *Melicocca bijuga* in the West Indies and Brazil; *Pappea capensis* at the Cape of Good Hope, &c. also yield edible fruits.

Natural Order 41. POLYGALACEÆ.—The Milkwort Order (*figs.* 891—896).—General Character.—*Shrubs* or *herbs*. *Leaves* alternate (*fig.* 891) or opposite, exstipulate, and usually simple. *Pedicels* with 3 bracts. *Flowers* irregular, unsymmetrical (*figs.* 891 and 892), and apparently papilionaceous (*fig.* 891), but only falsely so, as here the *wings* belong to the calyx, whereas in the true papilionaceous flower, which is only found in the Leguminosæ, they belong to the corolla. *Sepals* 5 (*fig.* 892, *s*), very irregular, usually distinct; of which 3 are placed exterior, and of these 1 is posterior and 2 anterior; the 2 interior are lateral, they are usually petaloid, and form the wings to the flower. *Petals* hypogynous, usually 3, more or less coherent, of which 1, forming the keel, is larger than the rest, and placed at the anterior part of the flower (*fig.* 892); the keel is either naked, crested, (*fig.* 891), or 3-lobed; the other 2 petals are posterior (*fig.* 892), and alternate with the wings and posterior sepal of the calyx, and are often united to the keel; sometimes there are 5 petals, (*fig.* 892), and then the 2 additional ones, *pr*, *pr*, are of small size, and alternate with the wings and anterior sepals. *Stamens* hypogynous, 8 (*figs.* 892, *e*, and 896), usually combined into a tube, unequal, the tube split on the side next to the posterior sepal (*fig.* 896); *anthers* clavate, innate, usually 1-celled (*fig.* 896), rarely 2-celled, opening by a pore at their apex (*fig.* 896). *Ovary* superior (*figs.* 892, *c* and 893, *ov*), 2—3-celled, one cell is frequently abortive; *ovules* solitary or twin, suspended; *style* simple (*fig.* 893, *styl*) curved, sometimes hooded at the apex; *stigma* simple (*fig.* 896, *stig.*) *Fruit* varying in its nature and texture (*fig.* 894), indehiscent, or opening in a loculicidal manner, occasionally winged. *Seeds* pendulous (*fig.* 894, *gr*), smooth or hairy, with a caruncula next the hilum (*figs.* 894, *r* and 895, *ar*); *embryo* straight or nearly so, in copious fleshy albumen, and with the radicle towards the hilum (*fig.* 895, *pl*).

Diagnosis.—Herbs or shrubs with exstipulate leaves. Flowers complete, hypogynous, irregular, unsymmetrical. Sepals and petals imbricated, not commonly corresponding in number, and usually arranged so as to form a *falsely* papilionaceous flower; odd petal anterior; odd sepal posterior. Stamens 8, hypogynous, usually combined; anthers generally 1-celled, with porous dehiscence. Fruit flattened, usually 2-celled, and 2-seeded. Seeds with abundant fleshy albumen, and with a caruncula next the hilum.

Distribution, &c.—Some genera of the order are found in

Fig. 891.

Fig. 892.

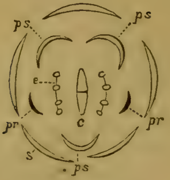
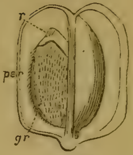


Fig. 893.

Fig. 894.



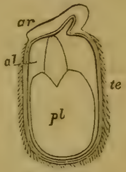


Fig. 895.

Fig. 896.

Fig. 891. A portion of the stem of the common Milkwort (*Polygala vulgaris*), with simple, alternate, exstipulate leaves; and irregular flowers.——*Fig.* 892. Diagram of the flower of the above plant. *s*. Sepals. *p s*, *p s*, *p s*. Posterior and anterior large petals. *p r*, *p r*. Lateral petals. *e*. Stamens. *c*. Carpels.——*Fig.* 893. Pistil of the above. *ov*. Ovary. *styl*. Style. *stig*. Stigma.——*Fig.* 894. Fruit with one cell opened. *per*. Pericarp. *gr*. Seed. *r*. Aril or caruncula.——*Fig.* 895. Section of seed. *te*. Testa. *ar*. Aril or caruncula. *al*. Albumen. *pl*. Embryo.——*Fig.* 896. Andrœcium of the same, with one-celled anthers dehiscing at their apex.

almost every part of the globe. The individual genera are, however, generally confined to particular regions, with the exception of the genus *Polygala*, which is very widely distributed, being found in almost every description of station, and in both

warm and temperate regions. *Examples:*—Polygala, Mundia, Monnina, Xanthopyllum, Soulamea. There are about 20 genera, and 490 species.

Properties and Uses. — The greater part of the plants of this order are bitter and acrid, and their roots milky; hence they are frequently tonic, stimulant, and febrifugal. Others are emetic, purgative, diuretic, sudorific, or expectorant. A few species have edible fruits, and others abound in a saponaceous principle. The following are the more important plants of the order:—

Polygala.—Many species of this genus have bitter properties, as *P. amara, rubella, vulgaris,* and *major;* they have been used as tonics, stimulants, diaphoretics, &c. *Polygala Senega,* the Senega Snake-root. — The root of this species was first introduced into medicine as an antidote to the bites of snakes. Various other species of *Polygala* have been reputed to possess similar properties, but they are generally considered as altogether useless in such cases. The root is officinal in this country, where it is used either in large doses, as an emetic and cathartic, or in small doses as a sialologue, expectorant, diaphoretic, diuretic, and emmenagogue. Its principal virtues are due to the presence of a very acrid, solid substance, which has been called Senegin, Polygalin, and Polygalic Acid. *P. sanguinea* and *purpurea,* in North America; *P. Serpentaria* at the Cape; *P. Chamæbuxus* in Europe; *P. crotalarioides* in the Himalayas, and other species, are said to possess somewhat similar properties, and one species, *P. venenosa,* a native of Java, has the acrid principle in so concentrated a state, as to render it poisonous *P. tinctoria,* an Arabian species, is used for dyeing.

Monnina polystachya and *salicifolia.*—The bark of the root of these plants is especially remarkable for the presence of a saponaceous principle; it is used in Peru as a substitute for soap, and for cleaning and polishing silver. It is moreover reputed to be a valuable medicine in diarrhœa and similar diseases.

Soulamea amara, a native of Molucca, is intensely bitter, and is said to be a valuable febrifuge, and also a medicine, which has been employed with very great success in cholera and pleurisy.

Natural Order 42. KRAMERIACEÆ. — The Rhatany Order. — *Diagnosis.* — This natural order comprises but the single genus *Krameria.* Lindley and some other botanists still retain it in the order Polygalaceæ, to which it was formerly always referred; but *Krameria* appears certainly to present sufficient claims to separation from that order. The *Krameriaceæ* resemble the *Polygalaceæ* in their exstipulate leaves; in having hypogynous unsymmetrical flowers; in their few stamens with porous dehiscence; and in their definite pendulous ovules. They are distinguished from the *Polygalaceæ* in their flowers not presenting a falsely papilionaceous arrangement; in their stamens being 1, 3, or 4, and distinct; in their ovary being 1-celled, or incompletely 2-celled; and in their exalbuminous seeds. By Braun and some other botanists, the genus *Krameria* has been referred to Leguminosæ.

Distribution, &c. — Found in the warm and temperate regions of Central America and South America. *Krameria* is the only genus; it contains 14 species.

Properties and Uses. — The roots of the different species of *Krameria* are intensely astringent; those of *Krameria triandra* are officinal in our pharmacopœias. They are commonly known under the name of Rhatany-roots. But little, if any, however, of the root of this species is now imported into Europe, our supplies

at present being chiefly derived from an unknown species, a native of New Granada, and which is called Savanilla Rhatany, to distinguish it from that obtained from the *Krameria triandra*, which is named Peruvian or Payta Rhatany. In France a kind of Rhatany is used, which is procured from the Antilles; this is known as West Indian Rhatany. Rhatany-root is used in medicine as an astringent, and is well adapted to all those diseases which require the employment of such medicines. It is also employed, mixed with equal parts of orris-rhizome and charcoal, as a tooth-powder. A saturated tincture of Rhatany-root in brandy is called wine-colouring, and is used in Portugal to give roughness to Port wines.

Natural Order 43. TREMANDRACEÆ.—The Porewort Order. —General Character.—Heath-like *shrubs*, with hairs usually glandular. *Leaves* exstipulate, alternate or whorled. *Flowers* axillary, solitary, pedicellate. *Sepals* 4 or 5, equal, slightly coherent, deciduous, and with a valvate æstivation. *Petals* corresponding in number to the sepals, deciduous, and with an involute æstivation. *Stamens* distinct, hypogynous, 8—10, 2 being placed before each petal; *anthers* 2 or 4-celled, with porous dehiscence (*fig.* 526). *Ovary* 2-celled; *ovules* 1—3 in each cell, pendulous; *styles* 1 or 2; *stigmas* 1—2. *Fruit* 2-celled, a capsule, with loculicidal dehiscence. *Seeds* pendulous, hooked at their apex; *embryo* straight, in the axis of fleshy albumen; *radicle* next the hilum.

Diagnosis.— Slender heath-like plants. Flowers solitary, axillary, and regular. Calyx and corolla with a quaternary or quinary arrangement, deciduous; æstivation of calyx valvate, of the corolla involute. Stamens distinct, hypogynous, 2 opposite to each petal; anthers 2 or 4-celled, with porous dehiscence. Fruit capsular, 2-celled. Seeds pendulous, hooked at their apex; embryo straight, in the axis of fleshy albumen.

Distribution, &c.—All are natives of New Holland. *Examples:*—Tetratheca, Tremandra, Platytheca. There are 3 genera, including 16 species.

Properties and Uses.—Altogether unknown.

Natural Order 44. ACERACEÆ.—The Maple Order.—General Character.—*Trees*. *Leaves* opposite, simple, without stipules; *venation* usually radiate, rarely pinnate. *Flowers* often polygamous. *Calyx* with an imbricated æstivation, usually 5-partite, occasionally 4 or 9 partite. *Petals* imbricated, correponding in number to the divisions of the calyx, or altogether absent. *Stamens* usually 8, inserted on or around a fleshy hypogynous disk. *Ovary* superior, 2-lobed, 2-celled; *style* 1; *stigmas* 2; *ovules* in pairs. *Fruit* a samara, 2-celled (*fig.* 688). *Seeds* 1 or 2 in each cell, without an aril, exalbuminous; embryo curved, with leafy wrinkled cotyledons, and an inferior radicle.

Diagnosis.—Trees with opposite, simple, exstipulate leaves.

Flowers regular, unsymmetrical. Sepals and petals imbricated, the latter without any appendages on their inside. Stamens hypogynous, on a fleshy disk ; anthers bursting longitudinally ; ovary superior, 2-celled. Fruit a samara, 2-celled, each cell containing 1 or 2 seeds. Seeds without an aril, exalbuminous ; embryo, curved with an inferior radicle.

Distribution, &c.—The plants of this order are natives of the temperate parts of Europe, Asia, and North America. None have been found in Africa and the southern hemisphere. *Examples:*—Acer, Negundo, Dobinea. There are 3 genera, and 60 species.

Properties and Uses.—These plants are chiefly remarkable for their saccharine sap. Their light and handsome timber is also much used in turnery, for certain parts of musical instruments, &c.; and their bark is astringent, and is employed in different districts by the dyer, in the production of yellow, reddish-brown, and blue colours. The most important genus is

Acer.—Thus *A. saccharinum*, is the Sugar Maple. The Maple Sugar of America is obtained from this tree, by making perforations into its trunk at the commencement of spring, and boiling down the saccharine sap which then exudes to the crystallizing point. A few years since as much as 45 millions of pounds of Maple Sugar were annually produced in North America, but the quantity diminishes yearly, in consequence of the destruction of the native forests. *A. dasycarpum* and other species also yield sugar. The bark of *A. saccharinum* has been used in America in the production of a blue dye, and as an ingredient in the manufacture of ink. *A. campestre* and *A. Pseudo-platanus*, are common trees in Britain, and afford useful timber; the latter is commonly known under the names of the Sycamore, Greater Maple, and Mock-plane. It derives the latter name from the resemblance of its leaves to those of the true Plane-tree. Its wood is also used for making charcoal.

Natural Order 45. HIPPOCRATEACEÆ.—The Hippocratea Order.—General Character.—*Shrubs*, frequently with a climbing habit, and generally smooth. *Leaves* opposite, simple, with small deciduous stipules. *Calyx* 5-lobed, very small, persistent, imbricated. *Petals* 5, hypogynous, imbricated. *Stamens* 3, monadelphous; the coherent filaments forming a disc-like cup round the ovary; *anthers* with transverse dehiscence. *Ovary* superior, 3-celled; *style* 1; *stigmas* 1—3. *Fruit* either baccate, and 1—3-celled, or consisting of three samaroid carpels. *Seeds* definite, attached to axile placentas, exalbuminous; *embryo* straight; *cotyledons* flat, and of a somewhat fleshy nature; *radicle* inferior.

Diagnosis.—Shrubs with opposite simple leaves, and small deciduous stipules. Flowers small, regular, and unsymmetrical. Sepals and petals 5, hypogynous, imbricated, the former persistent. Stamens 3, hypogynous monadelphous; anthers with transverse dehiscence. Ovary 3-celled; style 1. Fruit baccate, or consisting of 3 samaroid carpels. Seeds definite, exalbuminous; embryo straight; radicle inferior.

Distribution, &c.—They abound principally in South America; some are also found in Africa and the East Indies. *Examples:*—Hippocratea, Tontelea, Diplesthes. There are 6 genera, and 86 species.

Properties and Uses.—Very little is known generally of the plants of this order. Some have edible fruits; this is the case with that of several species of *Tontelea* in Brazil, and in Sierra Leone with the fruit of *T. pyriformis*, which is described as very pleasant. *Hippocratea comosa* yields nuts of an oily and sweet nature.

Natural Order 46. MALPIGHIACEÆ.—The Malpighia Order.—General Character.—*Trees* or *shrubs*, often climbing. *Leaves* usually opposite or whorled, rarely alternate; *stipules* generally short and deciduous, sometimes larger and interpetiolar; the leaves are sometimes furnished with hairs, which are fixed by their middle, that is, peltate (*fig.* 128). *Flowers* perfect, or polygamous. *Calyx* 5-partite, persistent, frequently with glands at the base of one or all the divisions, imbricated, or rarely valvate. *Petals* 5, hypogynous, unguiculate; *æstivation* convolute. *Stamens* usually 10, monadelphous or distinct; *connective* fleshy, and elongated beyond the anther-lobes. *Ovary* generally consisting of 3 carpels, (rarely 2 or 4), partially or wholly combined; *ovules* 1 in each cell, pendulous from a long stalk; *styles* 3, distinct or united; *stigmas* 3, simple. *Fruit* drupaceous, samaroid, or a woody nut. *Seed* solitary, suspended, exalbuminous (*fig.* 747); *embryo* straight, or variously curved.

Diagnosis.—Trees or shrubs, with simple stipulate leaves. Flowers perfect or polygamous. Calyx and corolla with 5 parts; the sepals having usually large glands at the base, and imbricated or very rarely valvate; the petals unguiculate, without appendages, hypogynous, convolute. Stamens usually 10, sometimes 15, with a fleshy prolonged connective. Ovary usually composed of 3 carpels, or in any case not corresponding in number, or being any power of the three outer whorls; ovules solitary, pendulous from long stalks. Seeds exalbuminous, usually with a convolute embryo.

Distribution, &c. — They are almost exclusively natives of tropical regions. *Examples:*—Malpighia, Byrsonima, Bunchosia, Nitraria, Hiræa, Gaudichaudia. Lindley enumerates 43 genera, and 556 species.

Properties and Uses.—An astringent property appears to be most general in the plants of this order. Some have edible fruits; others are chiefly remarkable for their large showy flowers; while some present anomalous stems, the peculiarity of which consists in the presence of several woody axes without annual zones; and either surrounded by a common bark, or more or less separated from one another. The following may be mentioned as the most important plants belonging to the order:—

Malpighia glabra and *punicifolia* have edible fruits, which are used in the West Indies as a dessert, under the name of Barbadoes Cherries. Some *Malpighias*, and other plants of this order, have hairs which sting severely.

Byrsonima.—Some species have edible fruits. The fruit of *B. spicata* (*Bois-tan*) is used in dysentery. The *Byrsonimas* are however, principally re-

markable for their astringency. Thus, the bark of *B. crassifolia* is astringent, and is used internally as an antidote to the bite of the rattlesnake, and for other purposes where astringent medicines are desirable. The bark of other species is employed for tanning in Brazil. American Alcornoque bark, which is now imported into this country for the use of the tanner, is said to be the produce of *B. laurifolia*, *rhopalæfolia*, and *coccolobœfolia*.

Nitraria.—This genus is by some put into an order by itself called Nitraciaceæ. According to Munby, *N. tridentata* is the true Lotus-tree of the ancients. This is a native of the desert of Soussa, near Tunis, and its fruit is of a somewhat intoxicating nature.

Bunchosia armeniaca, a native of Peru, is said to have poisonous seeds.

Natural Order 47. Erythroxylaceæ.—The Erythroxylon Order.—*Diagnosis.*—This order is closely allied to Malpighiaceæ, and, in fact, it scarcely presents characters sufficient to warrant its separation from that order. Its distinctive characters, according to Lindley, are as follows:—the flowers arise from amongst numerous small imbricated scale-like bracts; the calyx has no glands; the petals have at their base two parallel membranous plates; the stigmas are capitate; the ovules are sessile and truly anatropal; and the embryo is straight. In all other respects, the Erythroxylaceæ resemble the Malpighiaceæ.

Distribution, &c.—The plants of this order abound in Brazil; many also occur in some other parts of South America, and the West Indies; and a few are scattered throughout many of the warmer regions of the globe. There is but one genus, *Erythroxylon*, belonging to the order, which includes 75 species.

Properties and Uses.—Some of the Erythroxylaceæ are tonic, others purgative, and others stimulant and sedative. The wood of *E. hypericifolium*, and the bark of *E. suberosum* are red, and are used in the preparation of dyes of that colour. The wood of others has a similar reddish appearance, and from this common colour of the wood the name of the genus is derived. The only important plant of the order is

Erythroxylon Coca. — The leaves of this plant are much used by the natives of Peru, and some other parts of South America, as a masticatory; for which purpose they are always taken with a very small quantity of an alkaline paste prepared from the ashes of different plants; or in some cases, lime is substituted. The Peruvian Indians have always ascribed to the coca, the most extraordinary virtues. Thus, they believe that it lessens the desire and the necessity for ordinary food, and in fact, that it may be considered as almost a substitute for food. Spruce says, that an Indian with a chew of Ipadú (the native name for coca of the Indians of the Rio Negro) in his cheek, will go two or three days without food, and without feeling any desire to sleep. Dr. Weddell, however, speaks far less highly of the virtues of coca. He states that it does not satisfy the appetite, but it merely enables those who chew it to support abstinence for a length of time without a feeling of hunger or weakness. The use of coca is also said to prevent the difficulty of respiration which is generally experienced in ascending long and steep mountains. Its excessive use is also stated to be very injurious, producing analogous effects to those occasioned by the immoderate consumption of opium and fermented liquors. It has been computed by Johnston, that the annual consumption of coca is 30,000,000 lbs., and that its chewing is indulged in by about 10,000,000 of the human race. The nature of the constituents, which thus give rise to the peculiar stimulating, hunger-allaying, and narcotic effects of coca, have not been satisfactorily determined.

Natural Order 48. CEDRELACEÆ.—The Mahogany Order.—General Character.—*Trees. Leaves* alternate, pinnate, exstipulate. *Calyx* 4—5-cleft, imbricated. *Petals* hypogynous, of the same number as the divisions of the calyx, imbricated. *Stamens* twice as many as the petals and divisions of the calyx, either united below into a tube, or distinct, and inserted into an annular hypogynous disk; *anthers* 2-celled, with longitudinal dehiscence. *Ovary* usually with as many cells as there are divisions to the calyx and corolla, or rarely only 3; *ovules* 4, or more, in two rows, anatropal; *style* and *stigma* simple. *Fruit* capsular (*fig.* 662), dehiscence usually septifragal. *Seeds* (*fig.* 662, *g*), flat, winged, attached to placentas in the axis; albumen thin or none; embryo straight, erect, with the radicle next the hilum.

Diagnosis.—Trees with alternate, pinnate, exstipulate leaves. Flowers hypogynous, symmetrical. Calyx and corolla with 4 or 5 divisions; both imbricated in æstivation. Stamens double the number of the petals; with united or distinct filaments, and inserted on a hypogynous disk. Ovary usually 4 or 5-celled, with 4 or more ovules; style simple. Fruit capsular; placentas axile. Seeds usually numerous, flat, winged; albumen thin or none; embryo straight, erect.

Distribution, &c.—Chiefly natives of the tropical parts of America and India; they are very rare in Africa. *Examples:*—Swietenia, Soymida, Chloroxylon, Flindersia. There are 9 genera, and 25 species.

Properties and Uses.—The plants of this order have fragrant, aromatic, tonic, astringent, and febrifugal properties, and many of them are valuable timber-trees. The following are the more important:—

Swietenia Mahagoni supplies the well-known valuable wood called Mahogany. This is chiefly imported from Honduras and Cuba, and also to some extent from other West Indian Islands. Its bark possesses febrifugal properties.

Soymida febrifuga. The Rohuna, or Red-wood Tree.—The bark is tonic, febrifugal, and astringent.

Chloroxylon.—The leaves of this genus are dotted, and yield by distillation an essential oil. *C. Swietenia* is the source of Indian Satin Wood, which is sometimes imported into this country for the use of cabinet-makers. According to Royle, this plant is one of those that yields the Wood-oil of India. (See p. 474).

Oxleya xanthoxyla furnishes the Yellow-wood of New South Wales.

Cedrela.—The bark of the plants of this genus is generally fragrant. *C. febrifuga*, *C. Toona*, and other species, have febrifugal and astringent barks; they have been used as substitutes for Cinchona. *C. Toona* furnishes a wood resembling mahogany, which is much used in the East Indies, and is occasionally imported into this country. It is termed Toon, Tunga, Poma, or Jeea-wood.

Natural Order 49. MELIACEÆ.—The Melia Order.—General Character.—*Trees* or *shrubs. Leaves* alternate, or rarely somewhat opposite, simple or pinnate, exstipulate. *Flowers* occasionally unisexual by abortion. *Calyx* 3, 4, or 5-partite. *Petals* equal in number to the divisions of the calyx, hypo-

gynous, sometimes coherent at the base; imbricated or valvate. *Stamens* twice as many as the petals, monadelphous; *anthers* sessile, placed within the orifice of the tube formed by the coherent filaments. *Disk* hypogynous, sometimes large and cup-like. *Ovary* compound, usually 2, 3, 4, or 5-celled, rarely 10 or 12-celled; *style* 1; *stigmas* separate or combined; *ovules* 1, 2, or rarely 4 in each cell. *Fruit* baccate, drupaceous, or capsular, in the latter case opening loculicidally; many-celled, or by abortion 1-celled. *Seeds* few, not winged, arillate or exarillate; *albumen* fleshy, or usually absent; *embryo*, generally with leafy cotyledons.

Diagnosis.—Trees or shrubs, with usually alternate, simple or pinnate, exstipulate leaves. Flowers hypogynous, and generally symmetrical. Calyx and corolla with 3, 4, or 5 divisions. Stamens twice as many as the petals, distinctly monadelphous; anthers sessile. Disk hypogynous, and often surrounding the ovary like a cup. Ovary 2—5, or 10, or 12-celled; style 1; ovules 1, 2, or 4, attached to axile placentas. Fruit succulent, or capsular with loculicidal dehiscence. Seeds few, not winged; albumen fleshy or absent.

This order is very nearly allied to Cedrelaceæ, and by some botanists, the latter order is included in it. The order Meliaceæ is chiefly distinguished from Cedrelaceæ by having more completely monadelphous stamens, by the possession of fewer seeds, and in those seeds being without wings.

Distribution, &c.—They are found more or less in all the tropical parts of the globe; but are said to be more common in America and Asia than in Africa. A few are extra-tropical. *Examples:* Melia, Aglaia, Lansium, Trichilia, Guarea, Carapa. There are 33 genera, and 150 species.

Properties and Uses.—These plants are generally remarkable for bitter, tonic, and astringent properties. Some are powerful purgatives and emetics, as *Guarea Aubletii*, *G. trichilioides*, *G. purgans*, *G. spiciflora*, and some species of *Trichilia*. These all require much caution in their administration, and in some cases are reputed poisonous. Some have edible fruits. The more interesting plants are the following:—

Melia Azedarachta. — This is the Neem-tree or Pride of India; it is also called the Margosa-tree. It possesses febrifugal properties. The pericarp yields by expression a fixed oil, which is used for burning, and is reputed antispasmodic. The tree also yields a kind of toddy, which is employed as a stomachic. The root of *M. Azedarach* is used in North America as an anthelmintic.

Aglaia odorata. — The flowers of this species are sometimes used to give a perfume to certain varieties of Tea.

Lansium. — This is a genus of plants inhabiting the East Indian Archipelago. They yield fruits which are much esteemed, and known under the names of Langsat or Lanséh, and Ayer-Ayer.

Milnea edulis also produces an agreeable fruit, which is eaten.

Carapa guineensis, or *Touloucouna.*— The seeds of this plant yield a fatty oil, called Kundah or Tallicoonah, which is purgative and anthelmintic; it is also adapted for burning in lamps, and for other purposes. The seeds of

C. guianensis also yield a somewhat similar oil, which possesses analogous properties. The bark of these species possesses febrifugal properties.

Natural Order 50. AURANTIACEÆ.—The Orange Order (*figs.* 897—899).—General Character.—*Trees* or *shrubs*. *Leaves*

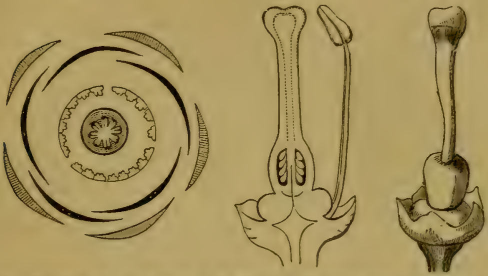


Fig. 897. *Fig.* 898. *Fig.* 899.

Fig. 897. Diagram of the flower of the Orange (*Citrus Aurantium*).——*Fig.* 898. Vertical section of the ovary, showing a portion of the disk at its base, and a solitary hypogynous stamen.——*Fig.* 899. Pistil of the Orange, with disk at its base, and the calyx: the petals and other stamens have been removed.

alternate, commonly smooth, exstipulate, dotted, and with the blade articulated to the petiole (*fig.* 300), which latter is usually winged. *Flowers* regular, fragrant. *Calyx* short (*fig.* 899), urn-shaped or campanulate, 3—5-toothed (*figs.* 897 and 899), withering. *Petals* equal in number to the divisions of the calyx (*fig.* 897), distinct or slightly coherent at the base, imbricated, inserted on a hypogynous disk. *Stamens* equal in number to the petals, or some multiple of them (*fig.* 897); *filaments* flattened at the base, either distinct, or coherent into one or several bundles (*fig.* 541); inserted along with the petals on the disk. *Disk* hypogynous, annular (*figs.* 898 and 899). *Ovary* many-celled (*fig.* 897); *style* 1 (*figs.* 898 and 899); *stigma* enlarged (*fig.* 899), and slightly divided; *ovules* solitary or numerous. *Fruit* indehiscent (*fig.* 695), constituting what has been termed a hesperidium, 1 or many-celled; occasionally its component carpels become more or less separated, and form what have been termed fingered Citrons and horned Oranges; or the number of carpels becomes increased (*fig.* 696), so that one fruit is produced within another. *Seeds* solitary or numerous; placentas axile (*figs.* 695 and 898), sometimes containing more than one embryo; the raphe and chalaza generally very evident, exalbuminous; *embryo* straight, with thick fleshy cotyledons, and a short radicle next the hilum.

Diagnosis.—Trees or shrubs with alternate, dotted, exstipulate leaves, having the blade articulated to the petiole. Flowers

regular. Calyx and corolla with from 3—5 divisions, the latter slightly imbricated and deciduous. Stamens hypogynous, equal in number to the petals or some multiple of them, with flat filaments, which are either distinct, or slightly coherent into one or more bundles. Disk hypogynous, and bearing the petals and stamens. Ovary many-celled; style 1. Fruit succulent. Seeds solitary or numerous; placentas axile; exalbuminous; embryo straight; radicle short; cotyledons thick and fleshy.

Distribution, &c.—The plants of this order are chiefly natives of the East Indies, but they are generally distributed by the agency of man throughout the warmer regions of the globe *Examples:*—Cookia, Feronia, Ægle, Citrus. There are 23 genera, and about 95 species.

Properties and Uses.—The plants of this order abound in receptacles containing essential oils, which render them fragrant; hence such oils are useful in perfumery, for flavouring, and for other purposes. These volatile oils are especially abundant in the leaves, the petals, and the rind of the fruit. The latter also contains a bitter tonic principle. The pulp of the fruit has an acid, or somewhat saccharine taste, and the wood is always hard, and of a compact nature. The more important plants are as follows:—

Cookia punctata.—This plant produces the Wampee-fruit, which is much esteemed in the islands of the Indian Archipelago, and in China.

Casimira edulis.—The fruit of this species is said by Seemann to be delicious, and also to produce a soporific effect.

Feronia elephantum.—This is a large tree, a native of India. A kind of gum exudes from its stem, which closely resembles Gum Arabic, and it is very probable that a part of the East India Gum imported into this country may be obtained from it. The young leaves have an Anise-like odour, and are used by the native practitioners of India for their stomachic and carminative effects. The fruit is known under the name of the Elephant or Wood-apple.

Œgle Marmelos. Indian Bael.—The bark of the root of this plant, as well as the dried unripe fruit, are astringent, and have been lately introduced into this country as remedies for diarrhœa and dysentery. Its leaves are also reputed useful in asthmatic complaints. The rind of the ripe fruit also yields a pleasant perfume, and its pulp is described as being very nutritious, and most pleasant to the taste; it possesses, moreover, laxative properties.

Citrus.—This is by far the most important genus of the order; the fruits yielded by the different species and varieties being highly valued for dessert and other purposes. The Orange, Lemon, Lime, Shaddock, Pompelmoose, Forbidden Fruit, Kumquat, and Citron, are all well known, although the species from which they are derived are not in all cases well defined. *Citrus Aurantium.*—The fruit of this plant is the Common Sweet Orange. Of this there are a great many varieties; the most important of which are the Common Orange, the Blood Red, the Maltese, and St. Michael's. The imports in 1851 from the Azores, Lisbon, Malta, and Sicily, were 300,500 packages, weighing 35,000 tons. Other varieties are sometimes imported from the Brazils, &c. as the Navel, and Tangerine Oranges. The Orange-tree is remarkable for the enormous number of fruits it is capable of yielding; thus, one tree will sometimes produce as many as 20,000 good oranges. The small unripe fruits of this species, as well as those of the Bitter Orange, form what are called *Orange-berries;* these are used for flavouring Curaçoa; and when polished by a lathe, they constitute the ordinary *issue peas* of the shops. The leaves of the Sweet Orange, as well as those of the Bitter Orange, by distillation with water, yield a volatile oil, which is called *Oil of Orange-leaf* or *Essence de petit grain;* that from the Bitter Orange is considered to be of the finest quality. From the

rind of the ripe fruit by distillation with water, a fragrant oil, named *Essential Oil of Sweet Orange*, is obtained. The flowers of this species, as well as those of the Bitter Orange, yield *Oil of Neroli;* that from the latter is preferred. The distilled water of these two species is named *Orange-flower Water.* It is to the presence of Oil of Neroli that the odour of Eau de Cologne is more particularly due. The rind of the Sweet Orange is an aromatic stimulant and tonic; and its juice is very extensively used as a refreshing and agreeable beverage at table; and also medicinally as a refrigerant. *Citrus Bigaradia* of Risso, or *Citrus vulgaris*, is the Bitter or Seville Orange. The leaves, flowers, and unripe fruits of this species yield by distillation similar essential oils to those obtained from analogous parts of the Sweet Orange. (See above.) The distilled water of the leaves is called *eau de naphre. Orange-flower Water* is generally prepared from the flowers of the Bitter orange, as it is considered more fragrant than that obtained from the Sweet Orange. The unripe fruits (as already noticed), like those of the Sweet Orange, are called *Orange-berries*, and are used likewise for making *issue peas*, and for flavouring Curaçoa. The rind of the ripe fruit yields by distillation a volatile oil, called *Essential Oil of Bitter Orange.* The chief use of the Bitter Orange is in the making of marmalade. The rind is also employed in medicine as a tonic and stomachic, and is more valuable in these respects than that of the Sweet Orange. The rind is also used for flavouring Curaçoa and other substances; and in the preparation of *candied orange-peel. Citrus Limonum.* The Lemon.—Of this we have several varieties; the more important of which are,—the Wax Lemon, the Imperial Lemon, and the Gaeta Lemon. They are chiefly imported from Sicily and Spain, the latter being the most esteemed. Both the rind and the juice are employed in medicine, and for other purposes; the former as an aromatic and stomachic, and for flavouring; the latter as an agreeable and refreshing beverage, and also for its refrigerant and antiscorbutic effects. The juice contains a large quantity of citric acid. *Candied Lemon-peel* is employed in confectionary, and as a dessert. The juice of Lemons, as well as that of the Lime, is largely imported, and used in the preparation of citric acid. The rind contains a large quantity of essential oil, which is generally obtained from it by expression, but it is of better quality if prepared by distillation; it is known as *Essential Oil* or *Essence of Lemon.* This oil is principally used as a flavouring agent in confectionary, and in medicine; and also in perfumery. *Citrus Limetta* is the source of the Lime. It is chiefly imported into this country in a preserved state, and in that condition it forms a most agreeable dessert. Its juice is also imported and largely employed with that of Lemons, in the preparation of citric acid, as already noticed. *Citrus Bergamia* is sometimes considered as only a variety of *Citrus Limetta.* This is the source of the Bergamot Orange. The rind, by expression or by distillation, like that of the Lemon, yields an essential oil, called *Oil* or *Essence of Bergamot*, which is largely used in perfumery. *Citrus medica.*—The fruit of this is the Citron. This is supposed to be the Hebrew Tappuach, which is translated in our version of the Old Testament as Apple-tree and Apples. The rind of this fruit only, is commonly imported into this country in a preserved state, and is used in confectionary. Its pulp is less acid and juicy than the Lemon, but it may be employed, as well as that of the Lime, for similar purposes. Two essential oils are obtained from *C. medica.* They are used in perfumery, and are called *Essence* or *Essential Oil of Citron*, and the *Essence* or *Essential Oil of Cedrat* or *Cedra.* The Citron, Lime, and Lemon are distinguished from Oranges, by having an adherent rind, by their more lengthened form, and by the possession of a more or less prominent protuberance at their apex. Besides the above fruits obtained from the genus *Citrus*, we have also, the Shaddock, from *C. Decumana;* the Forbidden Fruit, from *C. Paradisi;* the Pompelmoose, from *C. Pampelmos;* and the Kumquat of China from *C. japonica.*

Natural Order 51. VITACEÆ OR AMPELIDEÆ.—The Vine Order.—General Character.—Usually climbing *shrubs* (*fig.* 210), with a watery juice, the joints swollen and separable from each other. *Leaves* simple (*fig.* 210), or compound, opposite below, alternate above, stipulate or exstipulate. *Flowers* regular, small, green, stalked (*fig.* 403); *peduncles* sometimes cirrhose. *Calyx* minute, with the limb generally wanting. *Petals* 4 or 5, sometimes united at the base; *æstivation* in-

duplicate; inserted on a disk which surrounds the ovary, caducous. *Stamens* corresponding in number to the petals and opposite to them, also inserted on the disk (*fig.* 506); *filaments* distinct, or somewhat coherent at the base; *anthers* versatile, bursting longitudinally (*fig.* 506). *Ovary* superior, 2—6-celled, usually 2; *style* very short, simple; *stigma* simple (*fig.* 506). *Fruit* succulent (*fig.* 700), commonly termed a nuculanium, usually 2-celled. *Seeds* erect, few, usually 2 in each cell; *testa* bony; *albumen* hard; *embryo* erect; *radicle* inferior.

Diagnosis.—Shrubby plants, with simple or compound leaves, which are opposite below, and alternate above. Flowers small, green, regular. Petals and stamens corresponding in number, 4 or 5, the latter opposite to the petals, both inserted on a hypogynous disk; æstivation of petals induplicate; anthers opening longitudinally. Ovary superior, with a very short simple style and stigma; placentas axile. Fruit a nuculanium. Seeds few; testa bony; embryo erect in horny albumen.

Distribution, &c.—The plants of this order are found in warm and tropical regions of the globe. None are natives of Europe. The common Grape Vine, which is now completely naturalised in the south of Europe, and is cultivated nearly all over the globe where the temperature does not rise too high or fall too low, is supposed to be a native of the shores of the Caspian. *Examples:*—Cissus, Vitis, Ampelopsis, Leea. Some of the genera are not well defined. There are probably 8 genera, including 260 species.

Properties and Uses.—The leaves, stems, and unripe fruits of this order abound more or less in an acid juice, the acidity being chiefly due to the presence of tartaric acid and bitartrate of potash. As the fruit ripens, it generally loses its acidity, and becomes sweet, owing to the formation of Glucose or Grape Sugar. The more important plants are as follows:—

Cissus.—The leaves and fruits of some species, as *C. setosa*, *C. cordata*, &c., are acrid. A blue dye is obtained in Brazil from the leaves and fruit of *C. tinctoria*.

Ampelopsis (*Cissus*).—The species of this genus constitute the well-known climbing shrubs called Virginian Creepers. They are remarkable for their foliage assuming a crimson colour in the autumn, and from their peculiarly constructed tendrils.

Vitis vinifera.—This plant, commonly known as the Grape Vine, has followed the steps of man into almost every region of the globe where the climate is at all adapted to its growth. The varieties of the Vine are exceedingly numerous, being more than 300. The fruits, under the name of Grapes, are too well known to need any particular description. They have been in use for more than 4000 years for the making of wine, &c. Grapes when dried are called *raisins*. Of raisins we have several commercial varieties, the more important of which are Valentias, Malagas, Muscatels, Sultanas, and Smyrnas. The Muscatels or Raisins of the Sun, are considered the finest. The Sultanas are remarkable for the absence of seeds. About 12,000 tons of the above varieties are annually imported. Besides the above kinds, there is also a small variety of raisin, commonly known under the name of Currants; this name is a corruption of Corinth, where they were originally grown, but they are now obtained from Zante, and several other of the Greek Islands. About 20,000 tons are annually imported.

The leaf of the Vine is astringent, and has been used in diarrhœa; and the sap has been employed in France in chronic ophthalmia. *Vitis vulpina* and *Labrusca*, of North America, yield fruits which are known as Fox-grapes. These are similar, although inferior in their properties, to those of the Common Grape.

Natural Order 52. PITTOSPORACEÆ. — The Pittosporum Order. — General Character. — *Trees* or *shrubs*. *Leaves* simple, alternate, exstipulate. *Flowers* regular. *Sepals* 4 or 5, distinct or somewhat coherent, deciduous, imbricated. *Petals* hypogynous, corresponding in number to the sepals, sometimes slightly coherent, imbricated. *Stamens* 5, distinct, hypogynous, alternate with the petals; *anthers* 2-celled, with longitudinal or porous dehiscence. *Ovary* superior, 2—5-celled; *placentas* axile or parietal; *style* single; *stigmas* equal in number to the placentas; *ovules* numerous, horizontal or ascending. *Fruit* baccate, or capsular, with loculicidal dehiscence. *Seeds* numerous; *embryo* minute, in a large quantity of fleshy albumen.

Diagnosis. — Trees or shrubs, with simple, alternate, exstipulate leaves. Flowers regular. Sepals and petals 4 or 5, hypogynous, imbricated, deciduous. Stamens 5, hypogynous, alternate with the petals, with 2-celled anthers. Ovary superior; style single; stigmas equal in number to the placentas, which are 2 or more, and either axile or parietal; ovules anatropal, horizontal or ascending. Seeds numerous, with a minute embryo in copious fleshy albumen.

Distribution, &c. — They are chiefly Australian plants; but are occasionally found in Africa and some other parts of the globe. None, however, occur in Europe or America. *Examples:* — Pittosporum, Cheiranthera, Sollya, Billardiera. Lindley enumerates in his Vegetable Kingdom 12 genera, including 78 species.

Properties and Uses. — The plants of the order are chiefly remarkable for their resinous properties. Some have edible fruits, as certain species of *Billardiera*. A few are cultivated in this country on account of their flowers, as *Sollya*, *Billardiera*, &c.

Natural Order 53. CANELLACEÆ. — The Canella Order. — General Character. — "This name has been given to a supposed order of plants represented by *Canella alba*, a common West Indian aromatic shrub, with evergreen, coriaceous, obovate, alternate, stalked leaves, no stipules, and corymbs of purple flowers. The calyx is leathery, and consists of 3 blunt, tough permanent, concave sepals, which imbricate each other. The petals are 5, twisted in æstivation. Within these stands a tough truncated hypogynous cone, whose upper half, on the outside, bears about 20 linear, parallel, 2-celled anthers, which open longitudinally, and touch each other. Its ovary is ovate, and tapers into a stiff style, whose end is emarginate. According to Botanical writers, the stigma is permanent, and 2-lobed, while

the ovary is 3-celled, with more ovules than one, attached to the central angle. But I can find no such structure; on the contrary, although the stigma is very slightly emarginate, yet the ovary does not offer even a trace of two cells, but is absolutely 1-celled, with 2 or 3 half anatropal ovules hanging by long cords from a little below the dome of the cavity. (According to Richard, there are 6 funiculate ovules attached in pairs to the middle of the wall of the ovary at the same height.) Gaertner has figured what purports to be the fruit of this plant, representing it to have 3 cells, of which 2 are abortive, and 2 or 3 seeds in the perfect cell, somewhat rostrate, consisting of hard homogeneous albumen, and containing a very small curved cylindrical embryo, lying obliquely, with the radicle turned towards the rostrum."—*Lindley.*

Diagnosis.—By some authors the genus *Canella* is placed in the Guttiferæ, by others in Meliaceæ. This order is, however, at once distinguished from the *Guttiferæ*, by its general appearance; alternate leaves; longitudinal dehiscence of its anthers; absence of disk; presence of a style; and albuminous seeds: from the *Meliaceæ*, by its unsymmetrical flowers; twisted æstivation of its petals; absence of disk; and horny albumen.

Distribution, &c.—The order is said to contain 2 genera, and 3 species. They are natives of the West Indies and continent of North America. *Examples*:—Canella, Cinnamodendron.

Properties and Uses.—The plants of the order have aromatic, stimulant, and tonic properties. One plant is officinal in the British Pharmacopœias, namely:—

Canella alba. The Laurel-leaved Canella, or Wild Cinnamon.—The inner bark of this plant is the Canella of the shops. It has been confounded (as already noticed, p. 439), with Winter's Bark, and hence has been called *Spurious Winter's Bark.* It may be at once distinguished from it by the paler colour of its inner surface, &c., and by its chemical characteristics. In its properties it is a warm aromatic stimulant and tonic. In America it has been employed as an antiscorbutic. In the West Indies, and in some parts of Europe, it is used as a spice. It has an odour intermediate between cloves and cinnamon. By distillation it yields a volatile oil, which is said to be sometimes mixed with, or substituted for, Oil of Cloves.

Cinnamodendron axillare, a native of the Brazils, and the other species of the genus, have aromatic barks, which possess similar properties to that of *Canella alba.*

Natural Order 54. Brexiaceæ.—The Brexia Order.—*Diagnosis.*—*Trees*, with coriaceous, alternate, simple leaves, and small deciduous stipules. *Flowers* green, in axillary umbels. *Calyx* 5-parted, persistent, imbricate. *Petals* 5, hypogynous, twisted. *Stamens* hypogynous, equal in number to the petals and alternate with them, arising from a toothed disk; *anthers* 2-celled, with longitudinal dehiscence. *Ovary* superior, 5-celled; *ovules* numerous; *placentas* axile; *style* 1. *Fruit* drupaceous, 5-cornered, 5-celled, rough. *Seeds* numerous, horizontal, smooth; *embryo* straight; *albumen* (?) fleshy.

Distribution, &c.—Principally natives of Madagascar. *Ex-*

amples:—Ixerba, Brexia, Argophyllum, Roussea. There are 4 genera, and 6 species, according to Lindley.

Properties and Uses. — Altogether unknown.

Natural Order 55. OLACACEÆ.—The Olax Order.—General Character.—*Trees* or *shrubs*. *Leaves* alternate, exstipulate, simple, entire, coriaceous. *Flowers* small, generally fragrant. *Calyx* small, monosepalous; limb either obsolete, or existing in the form of little teeth, persistent, often becoming finally enlarged; *æstivation* imbricated. *Petals* 5 or 6, hypogynous, valvate in æstivation, distinct, or adhering in pairs by means of the stamens, frequently hairy on their inside. *Stamens* hypogynous, 5—10, usually in part sterile, the fertile stamens varying in number from 3—10, of which 5 or fewer are opposite to the petals; the sterile stamens are generally alternate to them, and appendiciform; inserted upon, or outside of a conspicuous disk; *anthers* 2-lobed, with longitudinal dehiscence. *Ovary* seated within the disk, unilocular at the summit, and imperfectly 2—5-celled at the base; *ovules* 2, 3, or 1, pendulous, attached to a free central placenta; *style* simple; *stigma* clavate, or 2—5-lobed. *Fruit* indehiscent, frequently surrounded by the enlarged calyx, 1-celled, 1-seeded. *Seed* pendulous, solitary, without integuments; *embryo* minute, at the base of abundant fleshy albumen; *radicle* near the hilum.

Diagnosis. — Trees or shrubs, with alternate, simple, entire leaves, without stipules. Flowers small, regular, axillary. Calyx minute, monosepalous, generally enlarging so as to cover the fruit. Petals hypogynous, valvate in æstivation. Stamens definite, partly sterile, and partly fertile; the latter opposite to the petals, inserted upon, or outside of a conspicuous disk; anthers 2-celled, bursting longitudinally. Ovary free, often imbedded in the disk; ovules pendulous from a free central placenta. Fruit drupaceous. Seed without integuments, solitary, pendulous; embryo minute; albumen fleshy.

Distribution, &c. — Natives of tropical or of sub-tropical regions. *Examples*:—Opilia, Olax, Liriosma, Heisteria, Ximenia, Cathedra. According to Miers, there are 23 genera; the number of species is doubtful.

Properties and Uses. — Unimportant. Some have fragrant flowers. The fruit of *Ximenia americana* is eaten in Senegal. The leaves of *Olax zeylanica* are used in salads, and the wood in putrid fevers. The wood of *Heisteria coccinea* is considered by some, to furnish the Partridge-wood of cabinet-makers, but Lindley says, that this is certainly a mistake.

Natural Order 56. ICACINACEÆ. — The Icacina Order. — *Diagnosis.* — This is an order of plants consisting of evergreen trees and shrubs, and formerly included in the order Olacaceæ; but, as shown by Miers, they are clearly distinguished from that order. "They differ most essentially in the *calyx* being

always small, persistent and unchanged, never increasing with the growth of the fruit; the *stamens* being always alternate with the petals, not opposite; the *petals* and *stamens* are never fixed on the margin of the conspicuous cup-shaped disk; the *ovary* is normally plurilocular with axile placentation, and when unilocular, this happens only from the abortion of the other cells, the traces of which are always discernible, never completely unilocular at the summit, and plurilocular at base, with free central placentation. In Icacinaceæ the ovules are suspended below the summit of the cell in pairs superimposed by cup-shaped podosperms; only one of these becomes perfected, and the seed is furnished with the usual integuments."

Distribution, &c.—"They are natives of tropical or nearly tropical countries; chiefly the East Indies, Africa, and South America, a single species being found each in New Holland, Norfolk Island, and New Zealand." *Examples*:—Icacina, Mappia, Stemonurus, Sarcostigma. There are 13 genera, and 65 species.

Properties and Uses. — Unknown.

Natural Order 57. CYRILLACEÆ. — The Cyrilla Order. — *Diagnosis.* — Evergreen shrubs, with alternate, exstipulate leaves, nearly related to *Olacaceæ*, but chiefly distinguished by their imbricate petals, which are altogether free from any hairiness on their inside; and by the stamens being all fertile, and, if equal in number to the petals, alternate with them.

Distribution, &c. — They are all natives of North America. *Examples*:—Cyrilla, Mylocaryum, Elliottia. There are 3 genera, and 5 species.

Properties and Uses. —Nothing is known of their properties and uses.

Natural Order 58. HUMIRIACEÆ. — The Humirium Order. — *Diagnosis.* — *Trees* or *shrubs* with a balsamic juice. *Leaves* alternate, simple, coriaceous, exstipulate. *Calyx* 5-parted, imbricated. *Petals* 5, imbricated. *Stamens* hypogynous, 20 or more, monadelphous; *anthers* 2-celled; *connective* elongated beyond the anther-lobes. *Ovary* superior, usually surrounded by a disk, 5-celled; *ovules* 1 or 2 in each cell, suspended; *style* simple; *stigma* 5-lobed. *Fruit* drupaceous, 5-celled, or fewer celled by abortion. *Seed* with a narrow embryo lying in fleshy albumen, orthotropal.

Distribution, &c. — Natives of tropical America. *Examples*: — Saccoglottis, Humirium, Vantanea. There are but 3 genera, and 18 species.

Properties and Uses. — A balsamic yellow liquid called Balsam of Umiri, is obtained from the incised stem of *Humirium floribundum*; this is reputed to resemble in its properties Copaiba and Balsam of Peru. Other species are said to yield useful balsamic liquids. The so-called balsamic liquid found in plants of this order, is probably not a true balsam, but an oleo-resin resembling Wood Oil and Copaiba.

Natural Order 59. RUTACEÆ.—The Rue Order (*figs.* 900 and 901).—General Character.—*Trees*, *shrubs*, or rarely *herbs*. *Leaves* exstipulate, opposite or alternate, simple or pinnated, dotted. *Flowers* perfect (*fig.* 564), regular or irregular. *Calyx* having 4—5 segments (*fig.* 900), imbricated. *Petals* equal in number to the divisions of the calyx (*fig.* 900), or wanting, rarely combined so as to form a monopetalous corolla; *æstivation* usually twisted, rarely valvate. *Stamens* equal in number, or twice (*figs.* 564, 596, and 900), or thrice as many as the petals, or rarely fewer by abortion, inserted on the outside of a cup-shaped, hypogynous disk (*fig.* 564). *Ovary* sessile (*fig.* 564), or supported on a stalk (*fig.* 609); it is composed of from 2 to 5 carpels, which are either distinct, or united so as to form a compound ovary having as many cells as there are component carpels; *style* simple (*fig.* 564), or divided towards the base; *ovules* 2, 4, or rarely more, in each carpel. *Fruit* capsular, its carpels either coherent, or more or less distinct. *Seeds* solitary or in pairs; *albumen* present or absent; *radicle* superior (*fig.* 901).

Fig. 900.

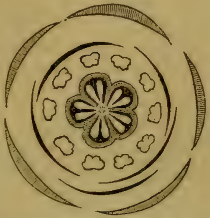


Fig. 901.

Fig. 900. Diagram of the flower of the Common Rue (*Ruta graveolens*).——*Fig.* 901. Vertical section of the seed of the same.

Diagnosis.—Herbs, shrubs, or trees, with exstipulate dotted leaves. Flowers perfect. Calyx and corolla with a quaternary or quinary distribution of their parts; the former with an imbricated æstivation, the latter twisted or valvate, and sometimes wanting. Stamens equal in number, or twice, or thrice as many as the petals, or fewer, inserted on the outside of a hypogynous disk. Ovary of from 2 - 5 carpels, separate or combined, either sessile, or elevated upon a stalk; ovules sessile. Fruit capsular. Embryo with a superior radicle. Albumen present or absent.

Division of the Order, &c. — The Rutaceæ have been divided into 2 sub-orders, as follows:—

Sub-order 1. *Ruteæ.* — Seeds containing albumen. Fruit with the sarcocarp and endocarp combined. *Examples*:—Ruta, Haplophyllum.

Sub-order 2. *Diosmeæ.* — Seeds exalbuminous. Fruit having the sarcocarp separate from the endocarp when ripe. *Examples*:—Barosma, Diosma.

These sub-orders are by no means well established.

Distribution, &c. — The Ruteæ are found chiefly in the

southern part of the temperate zone; the genera *Diosma*, *Barosma*, &c., abound at the Cape of Good Hope; other genera are found in Australia; and others in equinoctial America. There are 52 genera, and about 400 species.

Properties and Uses. — The plants of this order are generally characterised by a powerful penetrating odour, and bitter taste. In medicine they are employed as antispasmodics, tonics, febrifuges, diuretics, &c. The more important plants are as follows: —

Galipea officinalis and *Cusparia*.—Both these species appear to supply the Cusparia or Angustura Bark of the shops. This is imported directly or indirectly from South America. It is used in medicine as a stimulant tonic, and febrifuge, in small doses; while in large doses, it is somewhat emetic and purgative. This bark has fallen into disrepute on the Continent, in consequence of the substitution for it of a very poisonous bark obtained from the *Strychnos Nux-vomica*. At one time the substitution was so common, that the importation of Angustura Bark into Austria was prohibited, and the whole of it then found was ordered to be destroyed. At the present time such a substitution is rarely to be met with, although it occurred in Dublin some few years since.

Melambo Bark, which has somewhat similar properties to Angustura, is supposed to be also derived from a species of *Cusparia*.

Ticorea febrifuga, and *Esenbeckia febrifuga* are both natives of South America, and have febrifugal barks, which are used in some districts as substitutes for Peruvian Bark.

Correa alba, and other species.—The leaves are sometimes employed as a substitute for tea in Australia.

Barosma.—The leaves of several species of this genus, such as *B. crenata*, *crenulata*, *serratifolia*, &c., are used in medicine for their aromatic stimulant, antispasmodic, and diuretic properties. They seem also to have a specific influence over the urinary organs. They are commonly known under the name of *Buchu Leaves*. The plants yielding them are natives of the Cape of Good Hope. They owe their properties to a peculiar bitter principle called Diosmin or Barosmin, and a powerfully scented volatile oil. Buchu leaves are officinal in the British Pharmacopœias, but the exact species from which they are derived is by means well ascertained.

Dictamnus Fraxinella. False Dittany.—The root of this plant was formerly much used in medicine, and reputed to possess aromatic tonic, diuretic, antispasmodic, and emmenagogue properties, but it is now rarely or ever employed. It contains such a large amount of volatile oil as to render, it is said, the atmosphere around it inflammable in hot weather; we have, however, never succeeded in producing such an effect.

Ruta graveolens. Common Rue.—This plant, which is a native of Europe, has a very powerful, disagreeable, peculiar odour, which it owes to the presence of a volatile oil. Its taste is bitter and nauseous. It is used in medicine as an antispasmodic, anthelmintic, emmenagogue, stimulant, and carminative. This plant is said to be the Peganon of the New Testament. (*Luke* xi. 42.). *Ruta montana* possesses very acrid properties; so much so, indeed, as to blister the hands of those who gather it.

Natural Order 60. Xanthoxylaceæ. — The Prickly Ash Order. — *Diagnosis.* — The plants of this order are trees or shrubs, resembling, in almost all their characters, the Rutaceæ, with which they were formerly united. The only good character, indeed, by which the Xanthoxylaceæ may be distinguished from the Rutaceæ, is in their having constantly polygamous flowers. The fruit of Xanthoxylaceæ is also sometimes baccate and indehiscent, instead of being universally capsular; and the seeds are always albuminous, in place of being sometimes albuminous and at other times exalbuminous, as is the case in the Rutaceæ.

Distribution, &c. — These plants are found both in temperate and tropical regions of the globe; they are, however, most abundant in the tropics, and especially so in tropical America. *Examples*:—Xanthoxylon, Toddalia, Ptelea. There are 21 genera, and about 110 species included in this order.

Properties and Uses. — This order is almost universally characterised by pungent and aromatic properties, and sometimes by bitterness. In medicine, the plants belonging to it have been employed as stimulants, sudorifics, febrifuges, tonics, sialogogues, and emmenagogues. The more important are as follows:—

Xanthoxylon.—The species of this genus possess in a remarkable degree pungent and aromatic properties, hence they are popularly known under the name of Peppers in their native countries. In America they are also commonly known under the name of Prickly Ash. The fruit of *X. piperitum* is employed by the Chinese and Japanese as a condiment, and as an antidote against all poisons. It is commonly termed in commerce, Japanese Pepper. The aromatic pungent properties appear to be confined to the pericarp. Stenhouse has recently described two peculiar principles which he obtained from what he believed to be the true Japanese Pepper, viz., an oil and a stearopten; the former is a pure hydrocarbon, to which the aromatic odour of the pepper is due, and to which he has given the name of *Xanthoxylene;* the latter is a crystalline solid body consisting of carbon, oxygen, and hydrogen, but devoid of nitrogen when pure; this principle he has called *Xanthoxylin.** The root of *X. nitidum* is used as a sudorific, stimulant, febrifuge and emmenagogue, by the Chinese. *X. Clava* and *fraxineum* are also employed in America as sudorifics, &c., and are said to possess extraordinary power in exciting salivation. *X. caribæum* is reputed to be a good febrifuge. *X. Budrunga* has aromatic fragrant seeds resembling Lemon-peel; and the unripe fruit and seeds of *X. Rhetsa* have a taste like that of Orange-peel. The fruit and seeds of *X. hastile* are sometimes employed in India for the purpose of stupifying fish.

Toddalia aculeata.—The bark of the root is said to be febrifugal.

Ptelea.—The fruit is very bitter and aromatic, and has been used, according to Wight, as a substitute for Hops, and as a pickle.

Natural Order 61. OCHNACEÆ. — The Ochna Order. — General Character.—*Undershrubs*, or *smooth trees*, with a watery juice. — *Leaves* simple, stipulate, alternate. *Pedicels* jointed in the middle. *Sepals* 5, persistent, imbricate. *Petals* hypogynous, definite, sometimes twice as many as the sepals, deciduous, imbricated. *Stamens* equal in number to the sepals and opposite to them, or twice as many, or more numerous; *filaments* persistent and inserted on a hypogynous disk; *anthers* 2-celled, with longitudinal or porous dehiscence. *Carpels* corresponding in number to the petals, inserted on a large fleshy disk, or gynophore, which becomes larger as the carpels grow; *ovules* 1 in each carpel, erect or pendulous. *Fruit* consisting of several indehiscent, somewhat drupaceous, 1-seeded carpels.

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* Mr. Daniel Hanbury informs me that, the so-called Japanese Pepper, from which Dr. Stenhouse obtained the above principles, was not in reality that substance at all, but an analogous pepper, which was forwarded to him from China, and which he has proved to be the produce of *X. alatum*, a native of China and Nepaul. He also informs me that he thinks the pungency is due to a resinous substance, which is contained in the pepper, in addition to the Xanthoxylene and Xanthoxylin alluded to above.

Seed exalbuminous, or nearly so; *embryo* straight; *radicle* towards the hilum.

Diagnosis. — Undershrubs or smooth trees, with alternate, simple, stipulate leaves. Flowers hypogynous, perfect, regular, and symmetrical, with the pedicels articulated in the middle. Calyx and corolla with usually a quinary distribution, imbricated, the former persistent, the latter deciduous. Stamens hypogynous, 5, 10, or numerous; anthers 2-celled, with longitudinal or porous dehiscence. Style simple, with minute stigmas. Fruit consisting of a number of 1-seeded, indehiscent, succulent carpels, inserted on an enlarged fleshy disk. Seed with very little or no albumen; embryo straight, with the radicle towards the hilum.

Distribution, &c. — Natives chiefly of the tropical parts of India, Africa, and America. *Examples:* — Gomphia, Ochna, Godoya. There are 6 genera, and 82 species.

Properties and Uses.—The plants are generally remarkable for their bitterness. Some have been used as tonics and astringents. Some, as *Gomphia parviflora*, yield oil, which is used in Brazil for salads. In their properties generally, the Ochnaceæ much resemble the Simarubaceæ.

Natural Order 62. Coriarieaceæ.—The Coriaria Order.—*Diagnosis.*—This name is given to an order which includes but 1 genus, and 8 species; its affinities are by no means understood. It appears to be most nearly related to Ochnaceæ, in which it agrees in having its carpels distinct, and placed on an enlarged disk, or gynophore: but it is distinguished from that order by its opposite leaves; sometimes polygamous flowers; persistent fleshy petals; absence of style; and long linear distinct stigmas.

Distribution, &c.—Natives of the South of Europe, Chili, Peru, New Zealand, and Nepaul. *Example:*—Coriaria. This is the only genus; it contains 8 species.

Properties and Uses.—The plants of this order are generally suspicious, as they have sometimes produced poisonous effects. The fruits of some, however, are edible, as *Coriaria nepalensis*, a native of the north of India, and those of *C. sarmentosa*, a native of New Zealand; in the latter case, the pericarp is alone eaten, the seeds being poisonous. The fruits of *C. myrtifolia* and *ruscifolia* are very poisonous; these plants have been employed by dyers in the production of a black dye. The leaves of *C. myrtifolia* have been used on the Continent to adulterate Senna This is a most serious adulteration, as such leaves are poisonous. They may be at once distinguished from Senna-leaves by their two sides being equal and symmetrical at the base, while those of Senna are unequal. Chemically they are also distinguished from Senna, by their infusion producing a very abundant blue precipitate on the addition of sulphate of iron.

Natural Order 63. SIMARUBACEÆ.—The Quassia or Simaruba Order.—General Character.—*Shrubs* or *trees. Leaves* without dots, alternate, compound or sometimes simple, exstipulate. *Flowers* regular and symmetrical, axillary or terminal, perfect, or unisexual by abortion. *Calyx* imbricated, in 4 or 5 divisions. *Petals* equal in number to the divisions of the calyx, with an imbricated æstivation, sometimes united into a tube. *Stamens* twice as many as the petals, each inserted on a hypogynous scale; *anthers* with longitudinal dehiscence. *Ovary* stalked, 4 or 5-lobed, 4 or 5-celled, each cell with 1 suspended ovule; *style* simple; *stigma* with as many lobes as there are cells to the ovary. *Fruit* of 4 or 5 indehiscent, 1-seeded, drupaceous carpels, arranged round a common axis. *Seed* pendulous, with a membranous integument, exalbuminous, radicle superior, retracted within thick cotyledons.

Diagnosis.—Trees or shrubs, with alternate exstipulate leaves without dots. Flowers hypogynous, regular, symmetrical, with imbricated æstivation. Calyx, corolla, and stamens, with a quaternary or quinary distribution of their parts; each of the latter arising from a hypogynous scale, and with anthers bursting longitudinally. Ovary stalked, 4 or 5-celled; style simple; stigma 4 or 5-lobed. Fruit of 4 or 5 indehiscent, 1-seeded drupes, placed round a common axis. Seeds pendulous, exalbuminous, radicle superior.

Distribution, &c.—With the exception of one plant, which is a native of Nepaul, they are all found in the tropical parts of India, America, and Africa. *Examples:* — Quassia, Simaba, Simaruba, Ailanthus, Brucea, Spathelia. There are 17 genera, and about 50 species.

Properties and Uses.—A bitter principle is the most remarkable characteristic of the order; hence many of them are tonic and febrifugal. The more important plants are as follows: —

Quassia amara.—The wood of this plant is intensely bitter. It is a native of Surinam, &c., and was formerly much used as a febrifuge and tonic; the flowers are also stomachic. It is the original Quassia of the shops, but it is no longer imported; that now sold under the name of Quassia being derived from *Picrasma* or *Picræna excelsa*, a native of Jamaica, &c.; hence the latter may be called Jamaica Quassia, and the former Surinam Quassia. (See below.)

Picrasma (*Picræna*) *excelsa*, yields the officinal Quassia-wood of the Materia Medica. (See *Quassia.*) It is much used as a tonic, febrifuge, and stomachic, and it also possesses anthelmintic properties. An infusion of Quassia sweetened with sugar acts as a powerful narcotic poison on flies and other insects, hence it is used as a fly-poison. Like other pure bitters, its infusion may be also employed to preserve animal matters from decay. It is sometimes used by brewers as a substitute for hops, although prohibited by severe statutes in this and other countries. It owes its active properties chiefly to the presence of an intensely bitter crystalline substance, called Quassine or Quassite. In Jamaica this plant is known under the name of Bitter Ash or Bitter Wood.

Simaba Cedron.—The seeds of this plant are highly esteemed throughout Central America, where they are used for their febrifugal properties, and are thought to be a specific against the bites of venomous snakes, and other noxious animals. They have been used lately in this country for the latter purpose, but without any sensible effect.

Simaruba amara is a native of South America, and the West Indian Islands,

particularly Jamaica, where it is known under the name of Mountain Damson The bark of the root acts as a tonic, and has been used in diarrhœa, dysentery, &c. It contains Quassine, the same principle which has been found in Jamaica Quassia-wood. (See above.)

Many other plants belonging to the Simarubaceæ have analogous properties to the above, and are used, accordingly, in similar cases.

Natural Order 64. ZYGOPHYLLACEÆ. — The Bean-Caper or Guaiacum Order. — General Character. — *Herbs, shrubs,* or *trees. Leaves* opposite, stipulate, without dots, usually imparipinnate, rarely simple. *Flowers* perfect, regular, and symmetrical. *Calyx* 4 or 5-parted, convolute. *Petals* unguiculate, 4 or 5, imbricated in æstivation, hypogynous. *Stamens* 8—10, hypogynous, usually arising from the back of small scales; *filaments* dilated at the base. *Ovary* 4—5-celled, surrounded by glands, or a toothed disk; *style* simple; *ovules* 2 or more in each cell (*figs.* 643 and 644), pendulous, or rarely erect; *placentas* axile. *Fruit* capsular, dehiscing in a loculicidal manner, or separating into cocci 4 or 5-celled, and presenting externally as many angles or winged expansions as cells; rarely indehiscent. *Seeds* few, albuminous except in *Tribulus* and *Kallströmia; embryo* green; *radicle* superior; *cotyledons* foliaceous.

Diagnosis. — Herbs, shrubs, or trees, with opposite stipulate leaves without dots. Calyx and corolla with a quaternary or quinary distribution; the former convolute in æstivation, the latter with unguiculate petals and imbricated. Stamens 8—10, hypogynous, usually arising from the back of scales. Ovary 4—5 celled; style simple. Fruit 4 or 5-celled. Seeds few, with a little or no albumen; radicle superior; cotyledons foliaceous.

Distribution, &c. — They are generally distributed throughout the warm regions of the globe, but chiefly beyond the tropics. *Examples:* — Tribulus, Peganum, Fagonia, Zygophyllum, Guaiacum, Melianthus. There are 9 genera, and 100 species. *Melianthus* is by some botanists separated from the Zygophyllaceæ, and taken as the type of a new order, to which the name Melianthéæ has been applied. Melianthéæ is supposed to be allied to Geraniaceæ and Sapindaceæ.

Properties and Uses. — Some of the plants of the order are resinous, and possess stimulant, alterative, and diaphoretic properties; others are anthelmintic. The wood of the arborescent species is remarkable for its hardness and durability. The following are the more important plants: —

Tribulus terrestris is a prickly plant, which is abundant in dry barren places in the East. It is considered to be the Thistle mentioned in *Matt.* vii. 16., and *Heb.* vi. 8.

Peganum Harmala. — The seeds are used by the Turks as a spice, and to produce a red dye.

Zygophyllum Fabago. Bean-Caper. — It derives its common name from the circumstance of its flower-buds being used in some parts of the world as substitutes for the Common Capers. It is also reputed to possess anthelmintic properties. *Z. simplex* has a very fetid odour.

Larrea mexicana. — This plant is remarkable for having an odour resembling creasote, hence it is commonly known as the Creasote Plant.

Melianthus major.—The flowers of this species contain a large amount of saccharine matter, which is used for food by the natives of the Cape of Good Hope, where the plant abounds.

Guaiacum officinale.—The wood, and a resinous substance obtained from it are officinal in our pharmacopœias. They are commonly known in the shops as Guaiacum-wood, and Guaiacum Resin. The resin is generally procured by heating the wood, either by boiling its chips in salt water, or more commonly by burning it in the form of hollow billets in a fire, and catching the resin in a suitable vessel placed below as it flows from the hole in the burning wood. It also exudes to some extent spontaneously, and especially so when the tree is cut or wounded in any way. Both the wood and resin are used as stimulants, diaphoretics, and alteratives, chiefly in gout and rheumatism, and also in syphilitic and various cutaneous affections. The wood is known in commerce as Lignum Vitæ. It is remarkable for its hardness, toughness, and durability, which qualities render it very valuable for many purposes. The foliage of *Guaiacum officinale* is also used in the West Indies, on account of its detersive qualities, for scouring and whitening floors. *G. sanctum* has similar medicinal properties to the above, and yields an analogous resin.

Natural Order 65. LINACEÆ.—The Flax Order (*fig.* 902 and 903).—General Character.—*Herbs*, or rarely *shrubs*.

Fig. 902. *Fig.* 903.

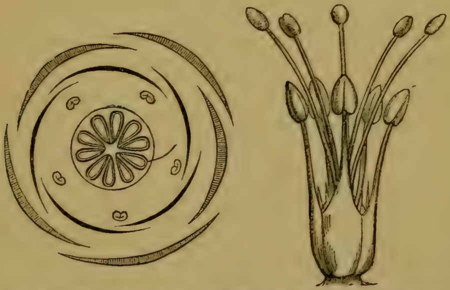


Fig. 902. Diagram of the flower of the Flax Plant (*Linum usitatissimum*).——*Fig.* 903. Essential organs of the same, showing the monadelphous stamens surrounding the pistil.

Leaves alternate or opposite, or rarely verticillate, entire, exstipulate. *Flowers* hypogynous, regular (*fig.* 902), symmetrical, generally very showy and fugacious. *Calyx* imbricated, with 3, 4, or 5 sepals (*fig.* 902), persistent. *Petals* 3, 4, or 5 (*fig.* 902), unguiculate, very deciduous, twisted in æstivation. *Stamens* 3, 4, or 5, coherent at the base so as to form a hypogynous ring (*fig.* 903), from which proceed 5 tooth-like processes (abortive stamens), which alternate with the fertile stamens, and are opposite to the petals; *anthers* innate (*fig.* 903). *Ovary* compound (*figs.* 902 and 603), its cells usually corresponding in number to the sepals; *styles* 3—5; *stigmas* capitate (*fig.* 903). *Fruit* capsular, many-celled, each cell more or less perfectly divided into two by a spurious dissepiment proceeding from the

dorsal suture, and having a single seed in each division (*fig.* 603). *Seed* with very little or no albumen; *embryo* straight, with the radicle towards the hilum.

Diagnosis. — Herbs, or very rarely shrubs, with exstipulate, simple, entire leaves. Flowers hypogynous, regular, symmetrical. Sepals, petals, and stamens 3—4—5 each; the sepals persistent and imbricate; the petals deciduous and twisted in æstivation; the stamens united at their base, and having little tooth-like abortive stamens alternating with them. Ovary 3—4—5-celled, styles distinct, stigmas capitate. Fruit capsular, many-celled, each cell more or less divided by a spurious dissepiment, and each division containing one seed. Seeds with little or no albumen, and having a straight embryo.

Distribution, &c. — Chiefly natives of the south of Europe and the north of Africa, but more or less distributed over most regions of the globe. *Examples:*—Linum, Reinwardtia, Cliococca, Radiola. There are 4 genera, and 90 species.

Properties and Uses. — The plants of this order are generally remarkable for the tenacity of their liber-fibres, and also for the mucilage and oil contained in their seeds; hence the latter are emollient and demulcent. A few are bitter and purgative. The most important genus is

Linum.—The liber-fibres of *Linum usitatissimum*, when prepared in a particular way, constitute *flax*, of which linen fabrics are made. Linen, when scraped, forms *lint*, which is so much used for surgical dressings. The short fibres of flax which are separated in the course of its preparation, constitute *tow*, which is much employed in pharmacy, surgery, and for other purposes. The seeds of the above plant, which is commonly known as the Flax Plant, are termed Linseed or Lintseed. Their seed-coat contains much mucilage, and their nucleus oil. The oil may be readily obtained from the seeds by expression, the amount depends upon the mode adopted, and varies from about 18 to 27 per cent. Linseed oil is especially remarkable for drying readily when applied to the surface of any body exposed to the air, and thus forming a hard transparent varnish. This peculiarity is much accelerated if the oil be previously boiled, either alone, or with some preparations of lead. The cake left after the expression of the oil is known as *Oil-cake*, and is employed as food for cattle; and when powdered it is commonly sold as Linseed Meal, which is much used for making poultices, and for other purposes. The Linseed Meal, however, as directed to be used in the London Pharmacopœia, is merely Linseed powdered; hence it contains the oil, which is not present in the ordinary meal. An infusion of Linseed is largely employed medicinally for its demulcent and emollient properties. The oil is extensively used in the arts, &c.; and is found to be a valuable application to burnt or scalded parts, either alone, or combined with an equal quantity of Lime-water; this mixture is commonly known under the name of *Carron-oil*, a name derived from its having been extensively employed in the Carron Iron-foundry. Some patents have been taken out of late years for the manufacture of what has been called Flax-cotton, which it was believed could be used in manufacture in the same way as ordinary cotton, but the process, (which consisted essentially in reducing the common flax-fibres to a more minute state of division, by first steeping them in a solution of carbonate of soda, and afterwards in a weak acid solution), does not appear to have answered in a commercial point of view. *Linum catharticum*, commonly called Purging-flax, is a common indigenous plant. It possesses active purgative properties, and might be much more employed as a medicine than is the case at present. This, like many other of our native plants, is probably but little esteemed, on account of the facility with which it can be obtained. *Linum selaginoides*, a Peruvian species, is reputed to be bitter and aperient.

Natural Order 66. Oxalidaceæ. — The Wood-Sorrel Order (*figs.* 904—906). — General Character. — *Herbs*, or rarely

Fig. 904. *Fig.* 905. *Fig.* 906.

Fig. 904. Diagram of the flower of *Oxalis*.——*Fig.* 905. Vertical section of the flower of the same.——*Fig.* 906. Vertical section of the seed.

shrubs, or *trees*, generally with an acid juice. *Leaves* alternate, or rarely opposite, usually compound, or occasionally simple; generally with stipules, or rarely exstipulate. *Flowers* regular and symmetrical. *Sepals* 5 (*fig.* 904), persistent, imbricate, occasionally slightly coherent at the base. *Petals* 5 (*fig.* 904), hypogynous (*fig.* 905), rarely wanting, unguiculate; *æstivation* twisted. *Stamens* double the number of the petals and sepals (*fig.* 904), arranged in two rows alternating with each other, the inner row longer than the outer (*fig.* 905) and opposite to the petals; *anthers* 2-celled, innate. *Ovary* superior (*fig.* 905), 3—5-celled, with as many distinct styles as there are cells; *stigmas* capitate, or somewhat bifid. *Fruit* usually capsular and 3—5-celled, and 5—10-valved, occasionally drupaceous and indehiscent; *placentas* axile (*fig.* 905). *Seeds* few, sometimes provided with a fleshy integument, which bursts with elasticity when the fruit is ripe, and expels the seeds; *embryo* (*fig.* 906) straight, in cartilaginous fleshy albumen; *radicle* long, and turned towards the hilum; *cotyledons* flat.

Diagnosis.—Herbs, or rarely shrubs, or trees, usually with compound exstipulate leaves. Stems continuous, and not separable at the joints. Flowers hypogynous, regular, symmetrical. Sepals, petals, and stamens with a quinary distribution; the sepals persistent and imbricated; the petals twisted in æstivation; the stamens commonly somewhat monadelphous, with 2-celled anthers. Styles filiform, distinct. Fruit 3—5-celled, without a beak. Seeds few, with abundant albumen, and a straight embryo.

Distribution, &c. — These plants are generally distributed throughout both the hot and temperate regions of the globe;

the shrubby species are, however, confined to the former. They are most abundant at the Cape of Good Hope, and in tropical America. *Examples:*—Oxalis, Averrhoa, Ledocarpum, Hugonia. There are 9 genera, and about 328 species enumerated by Lindley as belonging to the order.

Properties and Uses. — Chiefly remarkable for their acid juice, which is due to the presence of binoxalate of potash. They generally possess refrigerant properties. The fruits of some are eaten by the natives in certain parts of the East Indies, but they are too acid to be acceptable to Europeans, who, however, use them as pickles. Some are remarkable for their sensitive leaves, and others have phyllodes.

Oxalis acetosella. Common Wood-Sorrel.—This plant is a common indigenous plant, abounding in woods. It has ternate leaves, and is considered by many to be the true Shamrock, as its leaves open about St. Patrick's Day. When infused in milk, or water, it forms a pleasant refrigerant drink in fevers. The leaves, taken as a salad, are antiscorbutic. *O. crenata*, a plant which is called Arracacha, together with others, as *O. Deppei*, *O. esculenta*, &c. have edible tubers, which are used as substitutes for potatoes in some districts. *O. anthelmintica*, the Mitchamitcho of Abyssinia, has very acrid tubers. These are much employed for their anthelmintic properties in that country, being frequently preferred to Kousso (*Brayera anthelmintica*), a plant belonging to the Rosaceæ, and which is also largely used in Abyssinia for a similar purpose. (See *Brayera anthelmintica*).

Averrhoa Bilimbi and *Carambola* yield acid fruits, known respectively under the names of Blimbing and Carambole. They are eaten by the natives of the East Indies, but are too acidulous for Europeans, who nevertheless used them for pickles.

Natural Order 67. BALSAMINACEÆ. — The Balsam Order. — General Character.—*Herbaceous plants* with succulent *stems* and a watery juice. *Leaves* alternate or opposite, simple, exstipulate. *Flowers* hypogynous, very irregular. *Sepals* 3—5, very irregular, deciduous, with an imbricated æstivation, the odd one spurred (*fig.* 777). *Petals* usually 4, 1 being abortive, distinct or irregularly coherent, deciduous, alternate with the sepals; *æstivation* convolute. *Stamens* 5, alternate with the petals, and somewhat united. *Ovary* composed of 5 carpels, united so as to form a 5-celled compound body; *style* simple; *stigma* more or less divided into 5 lobes. *Fruit* usually capsular, 5-celled, and dehiscing in a septifragal manner by 5 elastic valves, which become coiled up (*fig.* 907); *placentas* axile; sometimes succulent and indehiscent. *Seeds* solitary or numerous, suspended, exalbuminous; *embryo* straight.

Fig. 907.

Fig. 907. Capsule of Touch-me-not, (*Impatiens noli-me-tangere*), with recurved coiled-up valves.

Diagnosis. — Succulent herbaceous plants, with simple exstipulate leaves. Stems continuous and not articulated at the joints. Flowers hypogynous, very irregular. Sepals 3—5; petals usually 4; both irregular and de-

ciduous; æstivation of sepals imbricated; that of the petals convolute. Stamens 5. Ovary 5-celled; style simple. Fruit 5-celled, usually bursting with elasticity, without a beak. Seeds suspended, exalbuminous.

Distribution, &c. — A few are scattered over the globe; but they are chiefly natives of the Indies, growing generally in damp shady places, and where the temperature is moderate. *Examples*:—Impatiens, Hydrocera. There are but 2 genera, which include 110 species.

Properties and Uses. — They are said by De Candolle to be diuretic, but they may be generally considered as possessing properties of no importance.

Natural Order 68. GERANIACEÆ. — The Crane's-bill Order (*figs.* 908—911).— General Character. — *Herbs* or *shrubs*

Fig. 908.

Fig. 909.

Fig. 910.

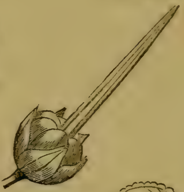


Fig. 911.

Fig. 908. A portion of the flowering stem of *Geranium sylvaticum*.——*Fig.* 909. The stamens and pistil of the same.——*Fig.* 910. The pistil partially matured, surrounded by the calyx.——*Fig.* 911. Transverse section of the seed.

with articulated swollen joints. *Leaves* simple, opposite or alternate, with membranous stipules. *Sepals* 5 (*fig.* 908), persistent, more or less unequal; *æstivation* imbricated. *Petals* 5 (*fig.* 908), or rarely 4 from abortion, unguiculate, hypogynous or perigynous; *æstivation* twisted (*fig.* 908). *Stamens* usually twice or thrice as many as the petals (*fig.* 909); some are, however, frequently abortive, hypogynous (*fig.* 909), and generally monadelphous, the alternate ones shorter and sometimes barren. *Carpels* 5, arranged around an elongated axis or carpophore (*fig.* 910); *styles* corresponding in number to the carpels, and adhering to the carpophore. *Fruit* consisting of 5 1-seeded carpels, which ultimately separate from the carpophore from below upwards by the curling up of the styles, which remain adherent at the summit (*fig.* 626). *Seeds* without albumen; *cotyledons* foliaceous, convolute (*fig.* 911).

Diagnosis. — Herbs, or shrubs, with simple leaves, membranous stipules, and articulated swollen joints. Flowers usually symmetrical. Sepals 5, imbricated. Petals twisted in æstivation. Stamens generally somewhat monadelphous. Fruit consisting of 5 carpels attached by means of their styles to an elongated axis or carpophore, from which they separate when ripe from below upwards, by the curling-up of the styles. Seeds 1 in each carpel, exalbuminous; embryo convoluted.

Distribution, &c. — Some are distributed over various parts of the world, but they abound at the Cape of Good Hope. *Examples*:—Erodium, Geranium, Pelargonium. Lindley enumerates 4 genera, and 500 species.

Properties and Uses. — Astringent, resinous, and aromatic qualities are the more important properties of the plants of this order. Many are remarkable for the beauty of their flowers.

Erodium.—The species are reputed to be astringent. *E. moschatum* is remarkable for its musky odour.

Geranium maculatum.—The root of this plant is a powerful astringent, for which purpose it is much used in North America, where it is called Alum-root. It contains much tannin. *G. parviflorum* produces edible tubers, which are known in Van Diemans Land under the name of native carrots.

Pelargonium.—The species of this genus are favourite objects of culture by the gardener, on account of the beauty of their flowers. They are chiefly natives of the Cape of Good Hope, but the species have been much improved by cultivation. They are commonly, but improperly, called Geraniums. In their properties they are generally astringent, but *P. triste* yields tubers which are eaten at the Cape of Good Hope.

Natural Order 69. TROPÆOLACEÆ. — The Indian Cress Order.—General Character.—Smooth twining or trailing herbaceous plants, with an acrid juice. *Leaves* alternate, exstipulate. *Flowers* axillary. *Sepals* 3—5 (*fig.* 778), the upper one spurred (*fig.* 454); valvate, or very slightly imbricated in æstivation. *Petals* (*fig.* 778), 1 to 5, hypogynous, more or less unequal; *æstivation* convolute. *Stamens* (*fig.* 778) 6—10, somewhat perigynous, distinct; *anthers* 2-celled. *Ovary* of 3 (*fig.* 778) or 5 carpels; *style* 1; *stigmas* 3 or 5. *Fruit* indehiscent, usually consisting of 3 carpels arranged round a common axis, from which they ultimately separate, each carpel containing one seed. *Seeds* large, exalbuminous; *embryo* large; *radicle* next the hilum.

Diagnosis. — Smooth trailing or twining herbs, with alternate exstipulate leaves, and axillary flowers. Flowers irregular and unsymmetrical. Sepals more or less valvate in æstivation, upper one spurred. Æstivation of petals convolute. Stamens more or less perigynous, distinct. Ovary superior, of 3 or 5 carpels, with one pendulous ovule in each; style single. Fruit without a beak, usually composed of three pieces, which are indehiscent, and each contains 1 seed. Seeds large, exalbuminous.

Distribution, &c. — Chiefly natives of South America. *Ex-*

amples:—Tropæolum, Chymocarpus. There are 4 genera, and about 40 species.

Properties and Uses. — Generally acrid, pungent, and anti-scorbutic, resembling the Cruciferæ. The unripe fruit of *Tropæolum majus*, which is commonly known as the Indian Cress or Garden Nasturtium, is frequently pickled, and employed by housekeepers as a substitute for Capers. Most of the *Tropæolums* have tuberous roots, some of which are edible, as *T. tuberosum.*

Natural Order 70. LIMNANTHACEÆ.— The Limnanthes Order. — *Diagnosis.*— This is a small order of plants included by Lindley in the Tropæolaceæ, with which it agrees in its general characters; but it is at once distinguished from that order by having regular flowers; more evidently perigynous stamens; and erect ovules. It forms a sort of transition order between Thalamifloral and Calycifloral Exogens, although, perhaps, it should be included in the latter.

Distribution, &c. — Natives of North America. *Examples:* Limnanthes, Flörkea. There are but 2 genera, and 3 species.

Properties and Uses. — In these they resemble the Tropæolaceæ.

We conclude our notice of the Natural Orders included under the Sub-class Thalamifloræ, by the following Artificial Analysis. It is founded upon that given by Lindley in his Vegetable Kingdom. The object sought to be attained in this analysis, is to facilitate the student in ascertaining the order to which a plant belongs; and, then, when the plant has thus been referred to its proper order, by turning to the description of that order as numbered below, he will find a more complete account, and be enabled to gain a perfect knowledge of it. It should be noticed that, however carefully such artificial analyses may be drawn up, it is almost impossible to render them universally applicable, on account of the extreme shortness of the characters which are necessarily employed.

Artificial Analysis of the Natural Orders in the Sub-class THALAMIFLORÆ.

(The numbers refer to the Orders in the present work.)

1. FLOWERS POLYANDROUS.—Stamens more than 20.

A. *Leaves without stipules.*

a. *Carpels more or less distinct, (at least as to the styles), or solitary.*

1. Stamens distinct.

Carpels immersed in a fleshy tabular thalamus . . . . *Nelumbiaceæ.* 11.

Carpels not immersed in a thalamus.

Embryo in a vitellus . . . . . *Cabombaceæ.* 9.

Embryo naked, very minute.

Seeds arillate . . . . . . *Dilleniaceæ.* 2.

Seeds exarillate. Albumen fleshy and homogeneous.

Flowers hermaphrodite . . . *Ranunculaceæ.* 1.

Flowers unisexual . . . . . *Schizandraceæ.* 6.

Seeds usually exarillate. Albumen ruminate . . . . *Anonaceæ.* 4.

2. Stamens united in one or more parcels.
   - Calyx much imbricated.
     - Seeds smooth . . . . *Hypericaceæ.* 36.
     - Seeds shaggy . . . . *Reaumuriaceæ.* 37.

b. *Carpels wholly combined into a solid pistil, with more than one placenta.*
   - Placentas parietal, in distinct lines.
     - Anthers versatile. Juice watery . . *Capparidaceæ.* 16.
     - Anthers innate. Juice milky . . . *Papaveraceæ.* 13.
   - Placentas parietal, spread over the lining of the fruit . . . . *Flacourtiaceæ.* 19.
   - Placentas covering the dissepiments . . *Nymphæaceæ.* 10.
   - Placentas in the axis.
     - Stigma large, broad, and petaloid . . *Sarraceniaceæ.* 12.
     - Stigma simple. Calyx much imbricated.
       - Leaves compound . . . . . . *Rhizobolaceæ.* 39.
       - Leaves simple.
         - Petals equal in number to the sepals.
           - Seeds few . . . . *Clusiaceæ.* 35.
           - Seeds numerous. Petals flat . . *Marcgraviaceæ.* 38.
           - Seeds numerous. Petals crumpled *Cistaceæ.* 18.
         - Petals not equal in number to the sepals. Styles not perfectly combined . . . . *Ternströmiaceæ.* 34.
     - Stigma 5-lobed. Stamens monadelphous *Humiriaceæ.* 58.

B. *Leaves with stipules.*

a. *Carpels more or less distinct, (at least as to the styles).*
   - Carpels numerous . . . . . . *Magnoliaceæ.* 3.

b. *Carpels wholly combined into a solid pistil, with more than one placenta.*
   - Placentas parietal . . . . *Flacourtiaceæ.* 19.
   - Placentas in the axis.
     - Calyx with an imbricated æstivation.
       - Flowers involucrate . . . . . *Chlænaceæ.* 33.
       - Flowers not involucrate . . . . *Cistaceæ.* 18.
     - Calyx with a valvate æstivation.
       - Stamens monadelphous. Anthers 2-celled.
         - Filaments united into a column. Stamens all perfect . . . . . . *Sterculiaceæ.* 29.
         - Filaments not united into a column. Stamens partly sterile . . . . *Byttneriaceæ.* 30.
       - Stamens monadelphous. Anthers 1-celled *Malvaceæ.* 28.
       - Stamens monadelphous. Calyx irregular, and enlarged in the fruit . . . *Dipteraceæ.* 32.
       - Stamens quite distinct . . . . *Tiliaceæ.* 31.

2. Flowers Oligandrous. — Stamens less than 20.

A. *Leaves without stipules.*

a. *Carpels more or less distinct, or solitary.*
   - Anthers with recurved valves . . . . *Berberidaceæ.* 8.
   - Anthers with longitudinal dehiscence
     - Albumen abundant, embryo minute.
       - Flowers unisexual. Seeds usually numerous . . . . *Lardizabalaceæ.* 5.
       - Flowers polygamous. Seeds solitary or twin *Xanthoxylaceæ.* 60.
       - Flowers perfect.
         - Embryo in a vitellus . . . . . . *Cabombaceæ.* 9.
         - Embryo not in a vitellus.
           - Albumen homogeneous.
             - Sepals 2 . . . . *Fumariaceæ.* 14.
             - Sepals more than 2 . . . . *Ranunculaceæ.* 1.

Albumen ruminate. Shrubs . . . *Anonaceæ*. 4.
Albumen in small quantity, or altogether wanting.
Flowers unisexual . . . . *Menispermaceæ*. 7.
b. *Carpels combined into a solid pistil or ovary.*
Placentas parietal.
Stamens tetradynamous . . . . . . *Cruciferæ*. 15.
Stamens not tetradynamous.
Large hypogynous disk.
Flowers tetramerous. Fruit closed at the apex . . . . *Capparidaceæ*. 16.
Flowers not tetramerous. Fruit usually open at the apex . . . . . *Resedaceæ*. 17.
Small hypogynous disk, or none.
Albumen abundant.
Flowers irregular . . . . . *Fumariaceæ*. 14.
Flowers regular. Sap milky. Fruit without central pulp . . . . *Papaveraceæ*. 13.
Fruit with central pulp, or fleshy.
Sap watery . . . . *Flacourtiaceæ*. 19.
Albumen in small quantity, or wanting.
Calyx tubular, furrowed . . . *Frankeniaceæ*. 23.
Placentas covering the dissepiments . . . *Nymphæaceæ*. 10.
Placentas axile.
Styles distinct to the base.
Calyx valvate . . . . *Vivianiaceæ*. 27.
Calyx much imbricated.
Seeds smooth. Petals unequal-sided, without appendages . . . . *Hypericaceæ*. 36.
Seeds shaggy. Petals unequal-sided, usually with appendages at the base . . *Reaumuriaceæ*. 37.
Seeds smooth. Petals equal . . . *Linaceæ*. 65.
Calyx slightly imbricated.
Petals not twisted in æstivation. Ovary with a free central placenta . . . *Caryophyllaceæ*. 26.
Styles more or less combined.
Fruit gynobasic.
Stamens arising from scales . . . *Simarubaceæ*. 63.
Stamens not arising from scales.
Styles wholly combined.
Flowers hermaphrodite . . . *Rutaceæ*. 59.
Flowers unisexual, or polygamous . *Xanthoxylaceæ*. 60.
Styles divided at the apex.
Flowers irregular. Fruit usually with elastic valves . . . . . . *Balsaminaceæ*. 67.
Fruit not gynobasic.
Calyx much imbricated, in an irregular broken whorl.
Flowers symmetrical . . . . *Clusiaceæ*. 35.
Flowers unsymmetrical.
Flowers regular.
Petals with appendages at their base. Leaves alternate . . *Sapindaceæ*. 40.
Petals without appendages at their base. Leaves opposite . *Aceraceæ*. 44.
Flowers irregular.
Flowers falsely papilionaceous.
Ovary 2—3-celled . . . *Polygalaceæ*. 41.
Flowers not papilionaceous in appearance. Ovary 1-celled . *Krameriaceæ*. 42.
Calyx but little imbricated, in a complete whorl.
Carpels 4 or more.
Seeds winged . . . . . . *Cedrelaceæ*. 48.
Seeds wingless.
Stamens united into a long tube . *Meliaceæ*. 49.
Stamens distinct, or nearly so

Leaves dotted. Seeds amygdaloid *Aurantiaceæ.* 50.
Leaves without dots. Seeds minute *Brexiaceæ.* 54.
Carpels less than 4.
Seeds comose . . . . . . *Tamaricaceæ,* 24.
Seeds not comose.
Ovules pendulous. Petals twisted in æstivation . . . . *Canellaceæ.* 53.
Ovules ascending, or horizontal. Petals imbricated in æstivation . *Pittosporaceæ.* 52.
Ovules pendulous. Petals imbricated in æstivation . . . . *Cyrillaceæ.* 57.
Calyx valvate, or but very slightly imbricated.
Anthers opening by pores . . . *Tremandraceæ.* 43.
Anthers with longitudinal dehiscence.
Calyx generally enlarging with the fruit *Olacaceæ.* 55.
Calyx small, not enlarging with the fruit . . . . *Icacinaceæ.* 56.
Stamens more or less perigynous.
Flowers irregular. Ovules pendulous *Tropæolaceæ.* 69.
Flowers regular. Ovules erect . . *Limnanthaceæ.* 70.

B. *Leaves with stipules.*

a. *Carpels distinct, or solitary.*
Anthers with recurved valves. Carpel solitary *Berberidaceæ.* 8.
Carpels several . . . . *Coriarieaceæ,* 62.

b. *Carpels wholly combined; with more placentas than one.*
Placentas parietal.
Leaves with circinate vernation . . . *Droseraceæ.* 22.
Leaves with involute vernation. Anthers crested, and turned inwards . . . *Violaceæ.* 20.
Stamens opposite to the petals. Anthers naked, and turned outwards . . . *Sauvagesiaceæ.* 21.
Placentas axile.
Styles distinct to the base.
Calyx much imbricated, in an irregular broken whorl.
Petals small, sessile . . . . . . *Elatinaceæ.* 25.
Calyx but little imbricated, in a complete whorl.
Petals conspicuous, stalked . . . *Malpighiaceæ.* 46.
Calyx valvate . . . . *Tiliaceæ.* 31.
Styles more or less combined. Fruit gynobasic.
Gynobase fleshy . . . . *Ochnaceæ.* 61.
Gynobase dry.
Leaves regularly opposite . . . *Zygophyllaceæ.* 64.
Leaves more or less alternate.
Fruit beaked . . . . . . *Geraniaceæ.* 68.
Fruit not beaked . . . . . . *Oxalidaceæ.* 66.
Styles more or less combined. Fruit not gynobasic.
Calyx much imbricated, in an irregular broken whorl.
Flowers surrounded by an involucre . *Chlænaceæ.* 33.
Flowers not surrounded by an involucre *Sapindaceæ.* 40.
Calyx but little imbricated, in a complete whorl.
Stamens 3. Sepals and petals pentamerous *Hippocrateaceæ.* 45.
Stamens more than 3.
Calyx glandular. Petals without appendages . . . . *Malpighiaceæ.* 46.
Calyx not glandular. Petals with appendages . . . . *Erythroxylaceæ.* 47.
Calyx valvate.
Stamens united by their filaments into a column . . . . *Sterculiaceæ.* 29.

Stamens not united into a column.
Stamens opposite to the petals if equal to them in number. Anthers versatile . . *Vitaceæ.* 51.
Stamens alternate with the petals if equal to them in number. Anthers not versatile . *Tiliaceæ.* 31.

In order to prevent the student being misled, and thus to refer plants to their wrong positions in the Vegetable Kingdom, it should be particularly noticed, that although the general character of the Thalamifloræ is to have dichlamydeous flowers and polypetalous corollas, yet exceptions do occur occasionally to both those characters. Thus, we find apetalous genera and species in *Ranunculaceæ*, *Menispermaceæ*, *Papaveraceæ*, *Flacourtiaceæ*, *Caryophyllaceæ*, *Sterculiaceæ*, *Byttneriaceæ*, *Tiliaceæ*, *Malpighiaceæ*, *Rutaceæ*, *Xanthoxylaceæ*, and *Geraniaceæ*. Again, in the orders *Anonaceæ* and *Rutaceæ*, we find some monopetalous species and genera. In Tropæolaceæ and Limnanthaceæ the stamens are more or less perigynous, instead of hypogynous, as is commonly the case in the Thalamifloræ. Perigynous stamens are also occasionally found in other Thalamifloral orders.

Sub-class II. — *Calycifloræ.*

1. Perigynæ.

Natural Order 71. Celastraceæ.—The Spindle-Tree Order.—General Character.—*Shrubs* or *small trees*. *Leaves* simple, generally alternate, or rarely opposite, with small deciduous stipules. *Sepals* 4—5, imbricated. *Petals* equal in number to the sepals, inserted on a large disk which surrounds the ovary; in *æstivation* imbricated, sometimes wanting. *Stamens* as many as the petals and alternate with them, inserted on the disk; *anthers* innate. *Disk* large, flat, and expanded. *Ovary* superior, surrounded by the disk, 2—5-celled, each cell 1 or many-seeded; *placentas* axile; *ovules* ascending, with a short stalk. *Fruit* superior, 2—5-celled, either drupaceous and indehiscent, or capsular with loculicidal dehiscence. *Seeds* ascending, with (*fig.* 735), or without an aril; *albumen* fleshy; *embryo* straight; *radicle* short, inferior; *cotyledons* flat.

Diagnosis.—Shrubby plants, with simple leaves, and small deciduous stipules. Flowers small, regular, and perfect; or rarely unisexual by abortion. Sepals and petals 4—5, imbricated in æstivation. Stamens equal in number to, and alternate with the petals, and inserted with them on a large flat expanded disk. Ovary superior, placentas axile. Fruit superior, 2—5-celled. Seeds ascending, arillate or exarillate, albuminous; embryo straight, radicle inferior.

Distribution, &c.—Chiefly natives of the warmer parts of Asia, North America, and Europe; they are also plentiful at the Cape of Good Hope. Generally speaking the plants of the order are far more abundant out of the tropics than in them. *Examples:*—Euonymus, Catha, Celastrus, Ptelidium, Elæodendron, Caryospermum. There are 30 genera, and 260 species.

Properties and Uses.—Chiefly remarkable for the presence of an acrid principle. The seeds of some contain oil. The more important plants are as follows:—

Euonymus europæus, is the common Spindle-tree of our hedges. In France, the charcoal which is prepared from the wood, is used in the manufacture of gunpowder; while the young shoots, in a charred condition, form a kind of drawing-pencil. The seeds are reputed to be purgative and emetic, and are also said to be poisonous to sheep. The seeds of some other species have similar properties. The bark of *E. tingens* has a beautiful yellow colour on its inside, which may be used as a dye.

Catha edulis and *spinosa*.—The young slender shoots with the leaves attached, of these plants, constitute the Arabian drug called Kât, Khat, or Cafta. This is largely chewed by the Arabs, and is said to produce great hilarity of spirits, and an agreeable state of wakefulness. A decoction is also made from it, and used as a beverage like our tea; its effects are described as being somewhat similar to those produced by strong green tea, but the excitement of a more pleasing and agreeable nature. By some writers the term Kât is applied to the drug in its unprepared state, and Cafta to a preparation made from it.

Celastrus paniculatus or *nutans*.—The seeds of this plant yield an oil of a stimulating nature, which is sometimes used as a medicine in India. *C. scandens* and *senagalensis*, have purgative and emetic barks.

Elæodendron Kubu.—The drupaceous fruits of this species are eaten at the Cape of Good Hope.

Natural Order 72. Stackhousiaceæ. — The Stackhousia Order.—*Herbs* or rarely *shrubs*, with simple, entire, alternate minutely stipulate leaves. *Calyx* 5-cleft, with itstube inflated. *Petals* 5, united below into a tube, arising from the top of the tube of the calyx, and having a narrow stellate limb. *Stamens* 5, distinct, of unequal length, perigynous. *Ovary* superior, 3 or 5-celled, each cell containing one erect ovule; *styles* 3 or 5, distinct, or combined at the base. *Fruit* consisting of from 3—5 indehiscent carpels, attached to a central persistent column. *Seeds* with fleshy albumen; *embryo* erect; *radicle* inferior.

Distribution, &c.—Natives of New Holland. *Examples*:—Stackhousia, Tripterococcus. There are but 2 genera, and 10 species.

Properties and Uses.—Unknown.

Natural Order 73. Staphyleaceæ.—The Bladder-Nut Order. —*Shrubs*, with opposite or rarely alternate, pinnate leaves which are furnished with deciduous stipules and stipels. *Calyx* 5-parted (*fig.* 766), coloured, imbricated. *Petals* 5 (*fig.* 766), alternate with the divisions of the calyx, imbricated. *Stamens* 5 (*fig.* 766), alternate with the petals, and inserted with them on a large disk. *Ovary* superior, composed of 2 (*fig.* 766), or 3 carpels, which are more or less distinct; *ovules* numerous; *styles* 2 or 3, coherent at the base. *Fruit* fleshy or membranous. *Seeds* ascending, with a bony testa; *albumen* little or none.

Distribution, &c.—They are scattered irregularly over the globe. *Examples*:—Turpinia, Euscaphis, Staphylea. There are but 3 genera, and 14 species.

Properties and Uses.—The bark of some species is bitter and astringent, as that of *Euscaphis staphyleoides*. Others have oily and somewhat purgative seeds, as *Staphylea pinnata*, &c.

Natural Order 74. VOCHYSIACEÆ.—The Vochysia Order.—*Trees* or *shrubs*, with entire, usually opposite leaves, which are furnished at the base with glands or stipules. *Flowers*, very irregular, and unsymmetrical. *Sepals* 4—5, coherent at the base, very unequal, the upper one spurred, imbricated in æstivation. *Petals* 1, 2, 3, or 5, unequal, inserted upon the calyx, imbricated in æstivation. *Stamens* 1 to 5, usually opposite the petals, or rarely alternate, arising from the bottom of the calyx, most of them sterile. *Ovary* superior, or partially inferior, 3-celled, or rarely 1-celled; *placentas* axile; style and stigma 1. *Fruit* usually capsular, 3-cornered, 3-celled, with loculicidal dehiscence, rarely indehiscent and 1-celled. *Seeds* usually winged, without albumen, erect.

This order is generally placed near *Combretaceæ*, but it is readily distinguished from it, by its superior or nearly superior ovary, for which reason we place it near *Staphyleaceæ*. Lindley considers it most nearly allied to the *Violaceæ* and the *Polygalaceæ*.

Distribution, &c —Natives of equinoctial America. *Examples:*—Qualea, Vochysia, Salvertia. According to Lindley, there are 8 genera, and 51 species.

Properties and Uses.—Generally unimportant, although some are said to form useful timber..

Natural Order 75. RHAMNACEÆ.—The Buckthorn Order.—General Character.—*Shrubs* or *small trees*, which are often spiny. *Leaves* simple, alternate, or rarely opposite; *stipules* small, or wanting. *Flowers* small, usually perfect (*fig.* 771), sometimes unisexual. *Calyx* 4—5-cleft, with a valvate æstivation (*fig.* 771). *Petals* equal in number to the divisions of the calyx (*fig.* 771), and inserted into its throat, cucullate or convolute, sometimes wanting. *Stamens* equal in number to the petals (*fig.* 771), and opposite to them when present, and alternate to the divisions of the calyx. *Disk* fleshy. *Ovary* (*fig.* 771) superior or half superior, immersed in the disk, 2, 3, or 4-celled; *ovules* solitary. *Fruit* dry and capsular, or fleshy and indehiscent. *Seeds* one in each cell, erect, usually with fleshy albumen, but this is sometimes wanting, exarillate; *embryo* long, with a short inferior radicle, and large flat cotyledons.

Diagnosis. Small trees or shrubs, with simple leaves, and small, regular, usually perfect flowers; rarely unisexual. Calyx 4—5, parted, valvate. Petals and stamens distinct, perigynous, and equal in number to the divisions of the calyx; the petals sometimes wanting; the stamens alternate with the divisions of the calyx, and opposite the petals when these are present. Ovary more or less superior, surrounded by a fleshy disk. Fruit dehiscent or indehiscent, 2, 3, or 4-celled, with one erect seed in each cell. Seed usually albuminous, without an aril.

Distribution, &c.—Generally distributed over the globe except

in the very coldest regions. *Examples:*—Paliurus, Zizyphus, Hovenia, Rhamnus, Ceanothus, Discaria. There are 42 genera, and 250 species.

Properties and Uses.—Some of the plants of this order have acrid and purgative properties; others are bitter, febrifugal, and tonic. A few are used in the preparation of dyeing materials, and some few others have edible fruits. Some of the more important plants may be enumerated as follows:—

Ventilago Maderaspatana.—Pupli.—The bark of the root is used in India in the production of orange and other dyes.

Zizyphus.—Many species of this genus have edible fruits. Thus, the *Z. vulgaris*, *Z. Jujuba*, and others, yield the fruit, known under the name of jujube. *Z. Lotus* has also an edible fruit, which is esteemed by the Arabs, &c. This is generally supposed to be the Lotus of the ancients, and from which the Lotophagi received their name. By some, however, the Lotus of the ancients is supposed to be the *Nitraria tridentata*. (See Nat. Ord. Malpighiaceæ, p. 490.) The berries, or seeds of some species of *Zizyphus* are regarded as sedative, while those of *Z. Boclei* are reputed to be poisonous.

Sageretia theezans, is a native of China, where its leaves are used as a substitute for tea by the poorer inhabitants.

Hovenia dulcis.—The peduncles of this plant become ultimately enlarged and succulent, and are much esteemed in China, where they are eaten as a kind of fruit.

Rhamnus.—This genus is the most important in the order. Thus, *R. catharticus*, commonly called Buckthorn, produces a fruit which has been used for ages as a cathartic; it is, however, but rarely employed at the present day, on account of its violent and unpleasant operation. The bark of *R. Frangula*, the Black Alder, possesses purgative and alterative properties. It is reputed to be efficacious in various cutaneous affections, rheumatism, secondary syphilis, &c.; a greenish or yellowish green dye is made from the leaves. The colour called *Sap-green*, is prepared by evaporating to dryness, the juice of the Buckthorn berries previously mixed with lime. The unripe fruits of *R. infectorius*, are known in commerce under the name of *French Berries* (Graines d'Avignon of the French); while those of *R. amygdalinus*, constitute the berries called *yellow berries*, or *Persian berries*. Some authors say, that both the French and Persian berries are the produce of one species, the *R. infectorius*, and that the only difference between them is in size,—those called French or Avignon berries, being smaller, and not of such good quality as the Persian berries, which are obtained from the Levant. These berries produce a beautiful yellow colour, which is chiefly used for dyeing morocco leather. *R. saxatilis* produces a fruit, which may be also employed for dyeing yellow. This plant is said by some authors to be the source of Persian berries. In Abyssinia, the leaves of *R. pauciflorus*, and the fruit of *R. Staddo*, both of which possess bitter properties, are employed as a substitute for hops in the preparation of beer. From *R. alaternus* a blue dye may be prepared. The Chinese green dye (*Lo-kao*), now much used in Europe, is prepared from *R. chlorophorus* (*globosus*) and *R. utilis*.

Ceanothus americanus.—The young shoots are employed as an astringent; and in New Jersey the leaves are dried and used as a substitute for tea; hence they are commonly known as New Jersey Tea.

Discaria febrifuga.—The root of this plant is used in Brazil as a febrifuge and tonic.

Gouania domingensis is reputed stomachic, and a few other plants of the order are regarded as possessing somewhat analogous properties.

Natural Order 76. ANACARDIACEÆ.—The Cashew-Nut or Sumach Order.—*Trees* or *shrubs*, with alternate, simple or compound leaves, which are exstipulate, and without dots. *Flowers* regular, small, and frequently unisexual. *Calyx* persistent, with usually 5, or sometimes 3, 4, or 7 lobes. *Petals* equal in number to the divisions of the calyx, perigynous, imbricated; sometimes absent. *Stamens* alternate with the

petals, and of the same number; or twice as many, or even more numerous; perigynous and coherent at the base if there is no disk, but if this is present then distinct and inserted upon it. *Disk* hypogynous, or wanting. *Ovary* usually single, 1-celled, generally superior, or very rarely inferior; *styles* 1, 3 or 4, or none; *stigmas* the same number as the styles; *ovules* solitary, attached to a long funiculus which arises from the base of the cell. *Fruit* indehiscent, drupaceous or nut-like. *Seed* without albumen.

Distribution &c.—The plants of this order are chiefly found in the tropical regions of the globe, although a few are found in the south of Europe, and in other extra-tropical warm districts. *Examples*:—Pistacia, Rhus, Melanorrhœa, Mangifera, Anacardium, Semecarpus, Spondias. There are 49 genera, and about 100 species.

Properties and Uses.—They abound in a resinous or somewhat gummy, or an acrid, or milky juice, which is occasionally very poisonous, and sometimes becomes black in drying. The fruits and seeds of some species, however, are held in high estimation, and are largely eaten in certain parts of the world. Many plants of this order furnish varnishes. The more important plants are as follows:—

Pistacia Lentiscus, is the source of the concrete resin called *mastic* or *mastich*. This is chiefly employed dissolved in spirit of wine, or oil of turpentine, as a varnish and cement. It is principally obtained from the island of Chio, where this plant is much cultivated. *P. Terebinthus* is the source of the liquid oleo resinous matter, called *Chian Turpentine*. This becomes solid by keeping from the loss of its volatile oil. It has the general properties of the ordinary Turpentines, derived from some of the Coniferæ. This also, as its name indicates, is chiefly obtained from the island of Scio or Chio. *Pistacia vera* produces the fruit known as Pistachio or Pistacia-nut, the kernels of which are of a green colour, and have a very agreeable flavour. They are highly esteemed by the Turks and Greeks, and are occasionally imported into this country. *P. Khinjuk* and *P. Cabulica*, natives of Scinde, yield concrete resins resembling mastic.

Rhus. The Sumach.—Several species of this genus have more or less poisonous properties. They have generally a milky juice, which becomes black on exposure to the air; and the emanations from some of them excite violent erysipelatous inflammation upon certain individuals who are brought within their influence. *R. Toxicodendron* is the Poison-oak of North America. The leaves contain a peculiar acrid principle, upon which their medicinal properties appear to be due. They have been thought to be useful in old paralytic cases, and in chronic rheumatism. This plant is by some authors considered as merely a variety of *R. radicans*, which has similar properties to it. *R. venenata* is the Poison-ash or Poison-elder, and like the two former, has very poisonous properties. The above plants in a fresh state, ought to be very carefully handled, as their juices frequently cause violent erysipelatous inflammation. The bark of *R. Coriaria* is a powerful astringent, and is used in tanning; other species have similar properties. The fruit of *R. Coriaria* is acidulous, and is eaten by the Turks. The leaves of *R. Cotinus*, when dried and powdered, constitute the material called *Shumac* or *Sumach*, which has been employed in tanning and dyeing for ages. The wood is also known in commerce as *Young Fustic* or *Zante Fustic*. It is used for dyeing, and produces a rich yellow colour. This must not be confounded with *Old Fustic*, which is obtained from an entirely different plant (see *Maclura tinctoria*). *R. Metopium*, a native of Jamaica, furnishes the Hog-gum of that island, which is said to have astringent, diuretic, and purgative properties when given internally, and to act as a vulnerary when applied externally

to wounds, &c. From the fruits of *R. succedaneum*, and probably other species, Japanese Wax is obtained, which is now largely used in this country for candles, &c. (See Pharmaceutical Journal, vol. i. New Series, page 176).

Melanorrhœa usitatissima furnishes the varnish of Martaban.

Stagmaria verniciflua. is the source of a valuable hard black varnish, known in the Indian Archipelago under the name of *Japan Lacquer.*

Holigarna longifolia.—The fruits of this plant and those of *Semecarpus Anacardium*, furnish the black varnish of Sylhet, which is much used in India.

Mangifera indica.—The fruit of this plant is the Mango, which is so highly esteemed in tropical countries. Several varieties are cultivated, which differ very much in the size and flavour of their fruits.

Anacardium occidentale, the Cashew-nut, is remarkable for its enlarged fleshy peduncle, which is eaten as a fruit; and its juice when fermented, produces a kind of wine in the West Indies. Each peduncle bears a small kidney-shaped nut, the pericarp of which is very acrid, but the seeds are edible. By roasting the nut, the acridity is destroyed, and the seed then possesses a fine flavour.

Semecarpus Anacardium, is the source of the Marking Nut. These nuts are used extensively in the preparation of a black varnish. The seeds are edible like those of the Cashew. These nuts and the fruit of *Holigarna longifolia* (as before noticed), furnish the black varnish of Sylhet, used in the East Indies, for varnishing lacquer-work, and for marking linen, hence their common name.

Spondias purpurea, *S. Mombin*, and others, have edible fruits, called Hog-plums in the Brazils and West Indies. The fruit of S. *cytherea* or *dulcis*, a native of the Society Islands, is said to rival the Pine-Apple in flavour and fragrance.

Natural Order 77. Sabiaceæ.—The Sabia Order.—This is a small order of plants, containing but 2 genera and 9 species, which were formerly placed as doubtful genera of the Anacardiaceæ: but the *Sabiaceæ* differ from the *Anacardiaceæ*, in their stamens being opposite to the petals; in their distinct carpels; in their solitary ovules being attached to the ventral suture; and in other characters. Miers and Blume regard the Sabiaceæ as related to Menispermaceæ and Lardizabalaceæ.

Distribution, &c.—Natives of the East Indies. *Examples:*—Sabia, Exitelia (?). Their properties are altogether unknown.

Natural Order 78. Connaraceæ.—The Connarus Order.—*Trees* or *shrubs*. *Leaves* alternate, without dots, compound, and generally exstipulate. *Flowers* usually perfect, rarely unisexual. *Calyx* 5-parted, imbricate or valvate in æstivation. *Petals* 5, inserted on the calyx, imbricate or valvate. *Stamens* 10, usually monadelphous, nearly or quite hypogynous. *Carpels* 1 or more; *ovules* 2, sessile, collateral, ascending, orthotropal. *Fruit* follicular. *Seeds* with or without albumen, arillate or exarillate; *radicle* superior, at the extremity most remote from the hilum.

Distribution, &c.—Natives of the tropics, and most common in tropical America. *Examples:*—Connarus, Omphalobium, Cnestis. There are 5 genera, and 41 species.

Properties and Uses.—Some have oily seeds; others have an edible aril, as some species of *Omphalobium*. The zebra-wood of the cabinet-makers, is said to be furnished by a very large Guiana tree,—the *Omphalobium Lamberti.*

Natural Order 79. AMYRIDACEÆ.—The Myrrh and Frankincense Order.—*Trees* or *shrubs*, abounding in a fragrant gum-resinous, or resinous juice. *Leaves* compound, frequently dotted. *Flowers* perfect, or rarely unisexual. *Calyx* persistent, with 2—5 divisions. *Petals* 3—5, arising from the calyx below a disk; *æstivation* valvate, or occasionally imbricate. *Stamens* twice as many as the petals, perigynous. *Disk* perigynous. *Ovary* 1—5-celled, superior, sessile, placed in or upon the disk; *ovules* in pairs, attached to a placenta at the apex of the cell, anatropal. *Fruit* dry, 1—5-celled; *epicarp* often splitting into valves. *Seeds* exalbuminous; *radicle* superior, turned towards the hilum.

Distribution, &c.—They have been only found in the tropical regions of America, Africa, and India. *Examples:*—Boswellia, Balsamodendron, Elaphrium, Icica, Bursera, Canarium, Amyris. Lindley enumerates 25 genera, including about 50 species.

Properties and Uses.—The plants of the order appear to be almost universally characterised by an abundance of fragrant resinous, or gum-resinous juice. Some are considered poisonous; others bitter, purgative, and anthelmintic; and a few furnish useful timber. The more important plants are as follows:—

Boswellia thurifera (*serrata*), supplies the gum-resin known as Indian Olibanum. The name Olibanum appears to be derived from the Greek λιβανος. It is the *Lebonah* of the Hebrews, and the Incense or Frankincense of the Bible. *B. glabra* supplies a somewhat analogous gum-resin. The gum-resin known in commerce as African or Arabian Olibanum, appears to be also derived from a species of *Boswellia;* according to Royle, the plant yielding it, is *B. floribunda*. Olibanum is chiefly used as a fumigation. *B. papyrifera* a native of Abyssinia, also yields a fragrant gum-resin. This tree is also remarkable on account of its inner bark, which peels off in thin white layers, which may be used as paper.

Balsamodendron Myrrha, is generally regarded as supplying the gum-resin known in commerce under the name of Myrrh. It is called in Hebrew *mor* or *mur*, and is mentioned in the Old Testament for the first time, in *Gen.* xxxvii. 25; hence it must have been in use for more than 3500 years. The plant or plants yielding Myrrh, for it is not yet altogether certain from whence it is derived, are natives of Africa and the adjoining parts of Arabia. Medicinally, myrrh is regarded as tonic, stimulant, expectorant, and antispasmodic, when taken internally; and as an external application it is astringent, and stimulant. The substance called *Balm of Gilead* or *Balm of Mecca*, and which is supposed to be the *Balm* of the Old Testament, is said to be procured from *Balsamodendron Gileadense*, although some authors say, that it is the produce of *B. Opobalsamum*. The gum-resin known as *Indian Bdellium* or *false myrrh*, (the *Bdellium* of Scripture), is also probably derived from species of *Balsamodendron*, namely, *B. mukul* and *B. pubescens*. Bdellium is the Googul or Guggur of the Beloochees, and the Mokul of the Persians. It is very similar to myrrh. *African Bdellium* is said to be the produce of *B. africanum*. The inner bark of *B. pubescens* peels off in thin white layers like that of *Boswellia papyrifera*, (see above).

Elaphrium elemiferum, yields a concrete resinous substance, known as Mexican Elemi. *E. tomentosum* also produces one of the resinous substances called Tacamahac.

Icica Icicariba is supposed to yield Brazilian Elemi. Other species produce somewhat analogous fragrant resins, as *I. Carana*, the source of American Balm of Gilead, *I. aracouchini*, &c. *I. altissima* furnishes the Cedar-wood of Guiana, of which there are several varieties. It is chiefly used for making canoes.

Bursera gummifera and *B. acuminata*, also yield fragrant resinous sub-

stances, — that from the former, is termed Chibou or Cachibou resin, — that from the latter, Resin of Carana.

Canarium commune (*C. zephyrinum* of Rumph), is the probable source of Manilla Elemi. *C. balsamiferum* of Ceylon, and *C. album*, a native of the Philippine Islands, also yield fragrant resinous substances resembling Elemi.

Amyris zeylanicum, *hexandra*, and *Plumieri*, have been also stated to yield a portion of the Elemi of commerce, but there is no proof whatever of this being the case. *A. balsamifera* is reputed to furnish one kind of *Lignum Rhodium*. *A. toxifera*, as its name implies, is regarded as poisonous.

Balanites ægyptiaca, has slightly acid leaves, which are reputed to be anthelmintic, while the unripe fruits are acrid, bitter, and purgative; they are eaten, however, when ripe. The seeds of this plant also yield by expression, a fixed oil of a fatty nature, called *zachun* in Egypt, where the plant is cultivated.

Natural Order 80. Leguminosæ or Fabaceæ.—The Leguminous Order (*figs.* 912 – 915).—General Character —

Fig. 912.

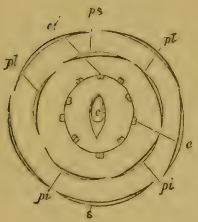


Fig. 913.

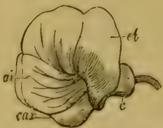
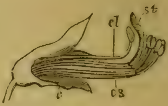


Fig. 914.



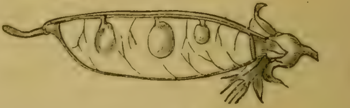


Fig. 915.

Fig. 912. Diagram of the flower of the garden pea (*Pisum sativum*). *s.* Sepals. *ps.* Superior petal. *pi, pi.* Inferior petals. *pl. pl.* Lateral petals. *e, et.* Stamens. *c.* Carpel.——*Fig.* 913. A flower of the above. *et.* Standard or vexillum. *ai.* Wings or alæ. *car.* Carina or keel enclosing the essential organs. *c.* Calyx.——*Fig.* 914. The essential organs of the same surrounded by the calyx *c.* *cs.* Bundle of nine stamens. *el.* Solitary stamen. *st.* Style and stigma——*Fig.* 915. The fruit of the same with one valve removed.

Herbs, shrubs, or *trees. Leaves* alternate, stipulate, usually compound (*figs.* 256 and 354). *Calyx* (*figs.* 912 *s* and 913 *c*), monosepalous, inferior, more or less deeply divided into 5 parts, the odd division being anterior. *Petals* usually 5 (*fig.* 912), or sometimes by abortion 4, 3, 2, 1, or none, inserted into the base of the calyx, equal or unequal, often papilionaceous (*fig.* 913); the odd petal, if any, posterior, (*fig.* 912). *Stamens* definite (*figs.* 912 and 914), or indefinite, usually perigynous, rarely hypogynous, distinct, or coherent in 1, 2 (*fig.* 540), or rarely 3 bundles; *anthers* versatile. *Ovary* superior, usually formed of 1 carpel (*figs.* 588 and 914), although rarely of 2 or 5; 1-celled, with 1, 2, or many ovules; *style* and *stigma* simple (*fig.* 588). *Fruit* usually a legume (*figs.* 653, and 673—675), sometimes a lomentum (*figs.* 670 and 676), and rarely a drupe. *Seeds*

1 or more, sometimes arillate, attached to the upper or ventral suture (*figs.* 653, and 915); *albumen* absent or present; *embryo* (*fig.* 160) straight, or with the radicle folded upon the cotyledons; *cotyledons* leafy or fleshy, and either hypogeal, or epigeal.

Diagnosis.—Herbs, shrubs, or trees. Leaves nearly always alternate and stipulate, and usually compound. Flowers regular or irregular, often papilionaceous. Calyx inferior, 5-parted; odd division anterior. Petals 5, or fewer by abortion, or none, perigynous, odd one when present, posterior. Stamens distinct, or coherent in 1 or more bundles. Ovary superior, simple, 1-celled; style simple, proceeding from the ventral suture. Fruit usually a legume, or sometimes a lomentum, and rarely a drupe. Seeds 1 or more, with or without albumen. *This order may be usually distinguished by having papilionaceous flowers, or leguminous fruit.*

Division of the Order, &c.—The order has been divided into three sub-orders as follows:—

Sub-Order 1. PAPILIONACEÆ.—Petals papilionaceous, imbricated in æstivation, and the upper or odd petal exterior. *Examples of the Genera:*—Baptisia, Gompholobium, Pultenæa, Leptosema, Liparia, Hovea, Heylandia, Lupinus, Dichilus, Ulex, Trifolium, Indigofera, Amorpha, Glycyrrhiza, Brongniartia, Astragalus, Vicia, Arachis, Ornithopus, Onobrychis, Amphicarpæa, Kennedya, Glycine, Dioclea, Mucuna, Phaseolus, Fagelia, Eriosema, Abrus, Dipteryx, Sophora.

Sub-Order 2. CÆSALPINIEÆ.—Petals not papilionaceous, imbricated in æstivation, and the upper or odd petal inside the lateral petals. *Examples of the Genera:*—Leptolobium, Cæsalpinia, Cassia, Swartzia, Tamarindus, Bauhinia, Copaifera, Ceratonia.

Sub-Order 3. MIMOSEÆ.—Petals equal, and valvate in æstivation. *Examples of the Genera:*—Parkia, Mimosa, Acacia.

Distribution, &c.—This is a very extensive order, and has some representatives in almost every part of the world. A considerable number of the genera are confined within certain geographical limits, while others have a very wide range. As a general rule, the *Papilionaceæ* are universally distributed, although most abundant in warm regions; while the *Cæsalpinieæ* and *Mimoseæ* are most common in tropical regions, but many of the latter are also to be found in Australia. There are about 520 genera, and 6650 species.

Properties and Uses.—The properties and uses of the plants of this order are exceedingly variable. Lindley remarks, that "The Leguminous Order is not only among the most extensive that are known, but also one of the most important to man, whether we consider the beauty of the numerous species, which are among the gayest coloured, and most graceful plants of every region; or their applicability to a thousand useful pur-

poses. The Cercis, which renders the gardens of Turkey resplendent with its myriads of purple flowers; the Acacia, not less valued for its airy foliage and elegant blossoms, than for its hard and durable wood; the Braziletto, Logwood, and Rosewoods of commerce; the Laburnum; the classical Cytisus; the Furze and the Broom, both the pride of the otherwise dreary heaths of Europe; the Bean, the Pea, the Vetch, the Clover, the Trefoil, the Lucerne, all staple articles of culture by the farmer, are so many Leguminous species. The gums Arabic and Senegal, Kino, Senna, Tragacanth, and various other drugs, not to mention Indigo, the most useful of all dyes, are products of other species; and these may be taken as a general indication of the purposes to which Leguminous plants may be applied. There is this, however, to be borne in mind, in regarding the qualities of the order in a general point of view; viz., that upon the whole it must be considered poisonous, and that those species which are used for food by man or animals, are exceptions to the general rule; the deleterious juices of the order not being in such instances sufficiently concentrated to prove injurious, and being, in fact, replaced to a considerable extent by either sugar or starch." In alluding to the properties and uses of the more important plants of the order, we shall take them under their respective sub-orders.

Sub-Order 1. PAPILIONACEÆ.—In this sub-order we have included a number of plants which are used as nutritious food by man or animals, such as peas (*Pisum*), Broad-beans (*Faba*), Kidney-beans, Scarlet-runners, and haricots (*Phaseolus*), Lentils (*Ervum*), Chick-peas (*Cicer*), Pigeon-peas (*Cajanus*, &c.) The seeds of the above plants, and many others, are commonly known under the name of pulse, and are too well known to need any detailed description. Lucerne and Medick (*Medicago*), Melilot (*Melilotus*) Clover (*Trifolium*), Tares and Vetches (*Ervum*, *Vicia*), Saintfoin (*Onobrychis*), and many others which are common fodder plants in different parts of the globe, also belong to this sub-order, and do not require any further notice. Some plants, or parts of plants of this sub-order are however poisonous, as the roots of the Scarlet-runner (*Phaseolus multiflorus*), the roots of *Phaseolus radiatus*, the seeds of *Lathyrus Aphaca*, the seeds and bark of Laburnums (*Cytisus alpinus* and *C. Laburnum*), the seeds of *Anagyris fœtida*, and it is also said by some, (although denied by Macfadgen), the seeds of *Abrus precatorius*, also the seeds of the Bitter Vetch (*Ervum Ervilia*), the juice of *Coronilla varia*, the leaves of some *Gompholobiums*, the leaves and young branches of *Tephrosia toxicaria*, the bark of the root of *Piscidia Erythrina*, &c. Perhaps the most virulently poisonous plant of the sub-order, is an unknown species, supposed to be allied to the genus *Dolichos*, the seeds of which are known under the name of the Ordeal-beans of Old Calabar, from their being used in that district for trials by ordeal.

The plants of the sub-order which require a more particular notice, are as follows: —

Baptisia tinctoria.—This plant is the Wild Indigo of the United States. It receives its common name from yielding a blue dye resembling indigo, although of far inferior quality to that substance. The root and other parts are reputed to be emetic and purgative.

Crotalaria juncea, is an Indian plant which furnishes a coarse fibre called *Sunn*, *Sun*, *Shunum*, *Taag*, or *Bengal Hemp*. This is sometimes confounded with *Sunnee*, a fibre obtained from *Hibiscus cannabinus*. (See *H. cannabinus*, p. 467.) *Crotalaria tenuifolia* another Indian plant, is the source from whence *Jubbulpore Hemp* is prepared.

Sarothamnus (*Cytisus*) *scoparius*, is the common Broom. The seeds and

tops in small doses are diuretic and laxative, and in large doses purgative and emetic. They appear to owe their properties to a peculiar alkaloid discovered by Dr. Stenhouse, and called by him *Spartine*. *Sarothamnus junceus*, the Spanish Broom, has similar properties.

Melilotus officinalis.—The flowers and seeds of this and other species possess a peculiar fragrancy, which is due to the presence of *Coumarine*. They are used to give the flavour to Gruyère and other kinds of Cheese.

Genista tinctoria, the Dyer's Broom, yields a good yellow dye, or when mixed with Woad (*Isatis tinctoria*), a green. (See p. 453.)

Trigonella Fœnum Græcum.— The seeds of this plant are used in veterinary medicine under the name of *Fœnugreek*.

Indigofera tinctoria, *cœrulea*, and probably some other species, when subjected to a peculiar process yield commercial indigo, one of the most important of dyeing materials, and of which nearly 4000 tons are annually imported into this country. It is very poisonous, but in proper doses it has been employed in epilepsy and erysipelas, but its value in such diseases is by no means well established.

Psoralea glandulosa.— The leaves are used in Chili as a substitute for Paraguay tea.

Glycyrrhiza glabra. Common Liquorice.—The roots or under-ground stems of this plant, as well as those of other species, particularly *G. echinata* and *glandulifera*, possess a remarkably sweet taste, which is due to the presence of an uncrystallizable sugar which is not susceptible of vinous fermentation, and to which the names of *Glycyrrhizin*, *Glycion*, or *Liquorice sugar*, have been given. Extract of liquorice root is imported in very large quantities into this country under the name of *liquorice juice*, or *Spanish* or *Italian juice* from the countries whence it is obtained. The Spanish juice is prepared from *G. glabra;* the Italian juice from *G. echinata*. The root and the extract of liquorice are employed in medicine as flavouring substances, and for their demulcent and emollient properties. Various preparations of liquorice are commonly kept in the shops, and sold under the names of *pipe liquorice*, *Pontefract lozenges*, *extract of liquorice*, *Solazzi juice*, *&c.*

Tephrosia Apollinea and *toxicaria* are used in Africa for the preparation of a blue dye resembling indigo. Several species of *Tephrosia*, particularly *T. toxicaria* are used as fish poisons. They stupify the fish which are then readily taken by the hand. It has been thought by some, that *T. toxicaria* would act on the human system like Digitalis, and hence might be used as a substitute for it in those parts of the world where that is not a native. The leaflets of *T. Apollinea* are sometimes employed in Egypt to adulterate Alexandrian Senna. They may be readily distinguished from Senna leaflets by their silky or silvery appearance, and by being equal-sided at the base

Robinia Pseud-acacia is the Locust tree. It is frequently cultivated in Britain, on account of its flowers and its hard and durable wood.

Colutea arborescens. Bladder-Senna.—The leaflets of this plant have been used on the continent to adulterate Alexandrian Senna. They are at once distinguished from it by their regularity at the base.

Astragalus verus, *gummifer*, *Creticus*, and other species, furnish Gum Tragacanth, or as it is frequently termed in the shops—*gum dragon*. It is used by our manufacturers for stiffening *crape*, &c.; in medicine it is employed for its demulcent and emollient properties, and as a vehicle for the exhibition of more active substances. Tragacanth exudes naturally, or from wounds made in the stems of the above mentioned plants. The seeds of *A. bœticus* are used as a substitute for coffee in some parts of Germany.

Orobus tuberosus. — The roots are occasionally eaten in the Highlands of Scotland, and in Holland.

Arachis hypogœa. — This plant is remarkable for ripening its legumes under the surface of the ground, hence it is commonly known under the name of *Ground Nut*. The seeds are used as food in various parts of the world, and are occasionally roasted and served up in the same manner as Chestnuts, as an article of dessert in this country. They yield by expression a fixed oil, which is employed very extensively in India for cooking, &c., where it is called *Katchung Oil*. The oil is also occasionally imported into this country, or it is obtained here by expression from the seeds. It is a very liquid oil, and is accordingly much employed for watches and other delicate machinery; also for burning and other purposes.

Coronilla Emerus has cathartic leaves. They have been used to adulterate

Senna on the continent. They form the *Sené Sauvage*, or Wild Senna of France.

Æschynomene paludosa.—The stems of this plant furnish Indian rice paper, the *Shola* of India. This must not be confounded with the Chinese rice paper. (See *Aralia*). They are remarkably light and spongy, and hence are commonly used for making floats and buoys for fishermen, and at Singapore, for the manufacture of very light hats. A fibre called Duchai Hemp, is obtained from *Æschynomene cannabina.*

Alhagi Maurorum, Camel's Thorn.—This plant and other species related to it, secrete in Persia and Affghanistan, a kind of manna. This substance is obtained by simply shaking the branches. It is highly esteemed by the Affghans as a food for cattle. It has been supposed to have been the manna upon which the Israelites were fed in the wilderness, but such an idea is undoubtedly incorrect.

Soja hispida.—The legumes of this plant are used in India, &c., in the preparation of a sauce called *Soy*. It is imported from thence in large quantities.

Mucuna pruriens.—The hairs covering the legumes of this species and those of *M. prurita*, are sometimes used as a mechanical anthelmintic, under the name of *Cowhage* or Cow-itch. An infusion of the root of *M. pruriens* is also used in India as a remedy for cholera. *M. urens* and *altissima* furnish a black dye.

Butea frondosa.—This plant is a native of India. It yields an astringent gum called *butea gum*, which resembles Kino in its properties, and is sometimes forwarded to this country under that name. It is used in India in diarrhœas and similar diseases, and also for tanning. &c. The dried flowers of this species, and those of *B. superba*, are known under the names of Tisso and Kessaree flowers. They are extensively used in India in the production of beautiful yellow and orange dyes, and have been imported into this country. The fibres of the inner bark of *B. frondosa* are known under the name of *Pulas cordage.*

Voandzea.—The seeds of this plant resemble those of the *Arachis hypogæa* in being edible. They are boiled and eaten as peas. Their native name in Surinam is *Gobbe.*

Abrus precatorius.—The seeds are used as beads, for making rosaries, necklaces, &c., hence their common name of *prayer-beads*. They are of a scarlet colour with a black mark on one side. They are reputed to be poisonous. The roots resemble those of the Liquorice plant, and hence the name of *Wild Liquorice* by which this plant is sometimes known.

Pterocarpus.—*P. Marsupium* is the source of the officinal Kino of our Pharmacopœias, which is known under the names of East Indian, Amboyna, or Malabar Kino, or in the shops as Gum Kino. It is a powerful astringent. *P. erinaceus*, a native of West Africa, yields a similar astringent substance, called African Kino. East Indian Kino is that commonly met with in this country. Some other species appear to yield similar products. *Red Sandal* or *Red Sander's Wood* is obtained from *P. santalinus*. It is used in medicine as a colouring agent, and also by the dyer for the production of red and scarlet dyes. It contains a peculiar colouring matter of a resinous nature called Santaline. *P. dalbergioides* is said to yield the Andaman Red Wood. It is a valuable timber tree, and is also useful as a dyeing material. The bark of *P. flavus* is used in China for dyeing yellow. *P. Draco* is one of the plants from which the Dragon's Blood of commerce is obtained. This is sometimes, but improperly, called Gum Dragon. The true Gum Dragon of the shops is yielded by a species of *Astragalus*. (See *Astragalus*, p. 527.)

Dalbergia.—Several species of this genus are good timber trees. The most valuable of them all is *D. Sissoo*. In India its wood is called Sissoo and Sheeshum. East Indian Ebony or Black Wood, is obtained from *D. latifolia*. (See also *Diospyros*)

Triptolomæa.—The Rose-wood of the cabinet-makers is said to be obtained from several species of this genus, natives of South America.

Andira inermis ; The Cabbage-Bark Tree.—The bark of this tree, known as Cabbage-bark or Worm-bark, was formerly much used as an anthelmintic. It possesses cathartic, emetic, and narcotic properties. In large doses it is poisonous. The wood is said by some authors to furnish the Partridge-wood of the cabinet-makers. By others this is said to be produced by *Heisteria coccinea* (*Olacaceæ*). (See p. 499.) *A. retusa* yields a bark with similar properties, which is known under the name of Surinam Bark.

Geoffroya vermifuga, *spinulosa*, and other species possess barks which have similar properties to those from the species of *Andira*.

Dipteryx odorata.— The seeds of this plant, which is a native of Guiana, have a very powerful and agreeable odour, which is due to the presence of a volatile oil containing Coumarine. They are used for scenting snuff and in perfumery, and are commonly known under the name of Tonquin or Tonka Beans. Coumarine is also present in other plants of this Sub-order, as in the seeds and flowers of *Melilotus officinalis* and *cœrulea*, as already noticed. Fragrant seeds are also obtained from *D. oleifera*. They are the Eboe-Nuts of the Mosquito shore.

Sophora japonica.—The dried flower-buds are extensively used in China, for dyeing yellow. They are known under the name of *Wai-fa*.

Bowdichia virgilioides.— The bark of this plant, with that of one or more species of *Byrsonima* (Malpighiaceæ), is said to form the American Alcornoco or Alcornoque Bark of commerce. (See *Byrsonima*, p. 489 and 490.) It is used by the tanners.

Myrospermum toluiferum.—Balsam of Tolu is obtained by making incisions into the bark of this plant. Balsam of Peru is also obtained from a species of *Myrospermum*, called by Pereira *Myrospermum of Sonsonate*, as it grows on the Sonsonate coast of San Salvador; from which district our supplies of Balsam of Peru are now obtained. Since the lamented death of Dr. Pereira the tree has been called by Dr. Royle *M. Pereira*, a name which, out of compliment to the memory of that distinguished man it is desirable to retain. By some authors *M. Peruiferum*, a native of Peru, is considered to be the source of the commercial Balsam; but this must be incorrect, as no supplies of Balsam are now obtained from Peru. Balsam of Peru is known in commerce under the names of Sonsonate or St. Salvador Black Balsam. Two other medicinal products are also derived from *M. Pereira*, namely, White Balsam, which is obtained by pressing without heat the interior of the fruit and seed; and Balsamito, or Essence or Tincture of Virgin Balsam, which is made by digesting the fruit (deprived of its winged appendages) in rum. A peculiar crystalline substance has been obtained by Stenhouse from White Balsam, to which he has given the name of Myroxocarpine.

Castanospermum australe.—The seeds when roasted are said to resemble in flavour the chestnut. The plant is a native of New South Wales.

Sub-Order 2. CÆSALPINIEÆ. — The plants of this sub-order are principally remarkable for their purgative properties. Many important dye-woods, and several tanning substances are also obtained from plants of this sub-order. The fruits of some again are edible, and none possess any evident poisonous properties. The more important are the following: —

Hæmatoxylon campechianum.—The wood is employed in dyeing, and as an astringent and tonic in medicine. It is commonly known under the name of Logwood. It contains crystalline colouring principles called *hæmatin* and *hæmatoxylin*.

Parkinsonia aculeata.— Useful fibres are obtained from the stems of this plant.

Guilandina Bonduc, the Nicker Tree. — The seeds are reputed to be emetic and tonic. They are very bitter. The bark also possesses bitter and tonic properties.

Poinciana pulcherrima.— The roots are said to be tonic, and the leaves to have purgative properties.

Cæsalpinia. — The twisted legumes of *C. coriaria* are powerfully astringent, and are extensively used in tanning under the name of Divi-divi or Libi-dibi. The legumes of *C. Papai* are employed for a similar purpose, but they are very inferior to them. They are called *Pi-pi*. *C. Sappan* furnishes the Sappan, Bookum, or Bukkum-wood of India. It is used for dyeing red. The roots of the same tree, under the names of Yellow-wood and Sappan-root, are sometimes imported from Singapore, and employed for dyeing yellow. *C. echinata* furnishes Nicaragua, Lima, or Peach-wood, which is very extensively used in dyeing red and peach-colour. *C. crista* is the plant from which Brazil-wood is obtained. It is used for dyeing yellow, rose-colour, and red. *C. Brasiliensis* furnishes another dye-wood, called Braziletto-wood, which produces fine red and orange colours. The exact species furnishing the above three dye-woods cannot, however, be said to have been altogether ascertained.

Cassia.—The species of this genus are generally characterised by purgative properties. The leaflets of several species furnish the Senna of commerce, of which there are several varieties. Some uncertainty, however, still prevails

as to the source of some of the commercial kinds. That variety known commonly as Alexandrian Senna is generally considered to be derived from *Cassia officinalis*, var. *lanceolata* (the *Cassia acutifolia* of Home and some other authors), and *C. obovata*. Pereira also thought that it sometimes contained the leaflets of *C. æthiopica*, but we have never succeeded in finding any in Alexandrian Senna. This is the kind generally most esteemed in this country, but it is frequently adulterated with the leaves of other plants, as those of *Solenostemma Argel*, *Tephrosia Apollinea*, &c., from which it is readily distinguished by the inequality of its leaflets at the base. The Common East Indian, Mecca, or Bombay Senna is supposed by Royle to be the produce of *C. officinalis*, var. *acutifolia ;* according to Pereira it is derived from *C. elongata* of Lemaire, while Forskäl states it to be from *C. lanceolata* of Forskäl and Lindley. Tinnivelly Senna is furnished by *C. officinalis*, var. *elongata* (*C. lanceolata* of Royle). It is a very fine kind. The above three varieties are those generally used in England, and are officinal in our Pharmacopœias. Other commercial varieties are Tripoli Senna, from *C. æthiopica ;* Aleppo Senna, from *C. obovata ;* and American Senna, from *C. marilandica*. *Cassia Fistula* (*Cathartocarpus Fistula*).—The fruit, which is indehiscent, and divided into a number of cells by spurious dissepiments (*fig.* 599), contains a reddish-black pulp with a sweetish taste, which possesses laxative and purgative properties. *C. braziliana*, probably only a variety of the preceding, has a larger longer and rougher fruit, which also possesses purgative properties. It is commonly used in veterinary medicine, and is known as Horse Cassia. The bark of *C. auriculata* is said by Roxburgh to be employed for tanning and dyeing leather. The flowers are also used for dyeing yellow. The seeds of *C. absus*, under the name of Chichon or Cismatan, are used in Egypt as a remedy in ophthalmia.

Tamarindus indica.—The fruit of this plant is the well-known Tamarind. It contains an agreeable acidulous, sweet, and reddish-brown pulp, which is employed medicinally in the preparation of a cooling laxative drink. When the pulp is mixed with sugar, it is frequently employed as a preserve.

Hymenæa Courbaril, the West-Indian Locust-tree, is supposed to furnish Gum Anime or East-Indian Copal. Some of the East-Indian Copal is, however, probably obtained from *H. verrucosa*. This, and other kinds of Copal, are extensively used in the preparation of varnishes. Brazilian Copal is considered to be furnished by several species of *Hymenæa*, and by *Trachylobium martianum*. At least three kinds of Copal are also obtained from Africa, under the respective names of African Copal, African Yellow-gum, and African Red-gum. Some of these are also, probably, derived from species of *Hymenæa*, and from *Guibourtia copallifera*. Mexican Copal is also supposed to be derived from a species of *Hymenæa*. The inner bark of *H. Courbaril* is said to possess anthelmintic properties. The seeds of the same plant are imbedded in a mealy substance, which is sweet and pleasant to the taste, and when boiled in water, and the mixture afterwards allowed to undergo fermentation, an intoxicating beverage is obtained. This tree grows to a large size, and its timber under the name of Locust-wood, is used by ship-carpenters.

Bauhinia Vahlii, *racemosa*, and *parviflora* furnish fibres which are used in making ropes. *B. retusa* produces a kind of gum. *B. variegata* has an astringent bark, which is used in medicine, and for tanning and dyeing leather. The buds and dried flowers of *B. tomentosa* are also astringent, and are employed in dysentery, &c. Other species of *Bauhinia* are used in Brazil for their mucilaginous properties.

Copaifera.—Several species of this genus, as *C. multijuga*, *C. officinalis*, *C. Langsdorfii*, *C. coriacea*, &c., yield the oleo-resin, commonly known under the name of Balsam of Copaiba. This is obtained by making incisions into the stems of the trees. *C. pubiflora*, and probably *C. bracteata* also, furnish the Purple Heart or Purple Wood of Guiana, which is largely employed for making musket-ramrods, &c.

Dialium indicum yields a fruit called the Tamarind Plum,' the pulp of which has an agreeable slightly acidulous taste, somewhat resembling that of the common Tamarind.

Codarium acutifolium and *obtusifolium* yield fruits which are known under the names of Brown and Velvet Tamarinds. They are both natives of Sierra Leone. The pulp of both species is eaten, and has an agreeable taste.

Mora excelsa.—This plant, which is a large tree, a native of Guiana, furnishes the Mora Wood employed largely for ship-building.

Ceratonia Siliqua.—The ripe fruit of this plant is known under the names

of Carob, Locust, St. John's Bread, and Algaroba Bean. Its pulp has a very sweet taste, and is supposed to have been the food of St. John in the wilderness. It is now largely imported into this country as a food for cattle.

Baphia nitida, a native of Sierra Leone and other parts of Africa, furnishes the dye-wood known under the name of Barwood or Camwood. It produces a brilliant red colour.

Sub-Order 3. MIMOSEÆ.—The plants of this sub-order are chiefly remarkable for yielding gum and astringent principles. Some few are reputed to be poisonous, as the *Acacia varians*, the root of a Brazilian species of *Mimosa*, the leaves and branches of *Prosopis uiliflora*, the bark of *Erythrophlœum guineense*, &c.

Erythrophlœum guineense. The Sassy Tree of Western Africa. —The bark under the name of "ordeal bark" or "doom bark," is used in certain parts of Africa as an ordeal, to which persons suspected of witchcraft, secret murder, &c., are subjected as a test of their innocence or guilt.

Adenanthera pavonina, a native of India, &c., produces a dye-wood, called Red Sandal-wood. This must not be confounded with the Red Sandal-wood already alluded to, as derived from *Pterocarpus Santalinus*. (See p. 528.) The seeds, under the name of Barricarri Seeds, are used in the northern parts of South America for making necklaces, &c. They are perfectly smooth, and have a bright red colour.

Prosopis pallida.—The legumes of this and some other species are very astringent, and have been used in tanning under the names of Algaroba or Algarobilla. In South America, a drink called Chica is prepared from the fruit of *Prosopis Algaroba*. The name of Chica was at first given to a fermented liquor of the Maize, but is now commonly applied in South America to several fermented drinks.

Acacia. — Various species of this genus yield gum. Thus, *A. vera* and *nilotica* of Delile, are the chief sources of Gum Arabic ; *A. gummifera*, of Barbary or Morocco Gum ; *A. Verek*, *vera*, *Seyal*, and others, of Gum Senegal : *A. arabica* and *speciosa*, of East Indian Gum ; *A. Karoo*, of Cape Gum ; and *A. decurrens*, *mollissima*, and *affinis*, of South Australian Gum. The extract prepared from the duramen or inner wood of *Acacia Catechu*, furnishes a kind of Catechu or Cutch, a powerfully astringent substance, containing much tannin, and largely employed in the processes of tanning and dyeing, and also to some extent in medicine. (See *Uncaria Gambir*.) The dried legumes of *A. nilotica* are imported under the names of Neb-neb, Nib-nib, or Bablah, and are also used by tanners on account of their astringent properties. The barks of *A. arabica* and *A. Catechu* possess similar properties, and are used extensively in India under the name of Babool. The extract of the bark of *A. melanoxylon*, an Australian species, is also a valuable tanning principle, and is frequently imported into this country for that purpose. The bark is also sometimes imported under the name of Acacia Bark. *A. formosa*, a native of Cuba, furnishes a very hard, tough, and durable wood, of a dull red colour, called Sabicu. This is the wood that was used in constructing the stairs of the Crystal Palace in Hyde Park, at the Great Exhibition in 1851, and which upon removal was found to be but little worn. The flowers of *A. Farnesiana* are very fragrant, and when distilled with water or spirit, yield a delicious perfume. *A. Seyal* is supposed to be the Shittah-tree or Shittim-wood of the Bible. By others, however, this has been thought to have been *A. vera*, and by some, *A. horrida*. The first is probably correct.

Natural Order 81. MORINGACEÆ.—The Moringa or Ben-Nut Order.—*Trees* with bi- or tri-pinnate leaves, and deciduous-coloured stipules. *Flowers* white, irregular. *Sepals* and *petals* 5 each; the former deciduous, petaloid, and furnished with a fleshy disk; *æstivation* imbricated. *Stamens* 8 or 10, placed on the disk lining the tube of the calyx, in two whorls, the outer of which is sometimes sterile; *anthers* 1-celled. *Ovary* stalked, superior, 1-celled, with 3 pariental placentas. *Fruit*, long, pod-shaped, capsular, 1-celled, 3-valved, with loculicidal dehiscence. Seeds numerous, without albumen.

Fig. 916.

Fig. 917.

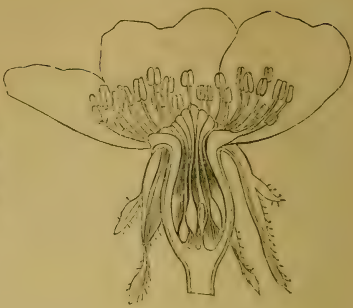


Fig. 918.

Fig. 919.

Fig. 916. Diagram of the flower of a species of Rose, with five sepals, five petals, numerous stamens, and many carpels.——*Fig.* 917. Vertical section of the flower of the Rose.——*Fig.* 918. Vertical section of the flower of the Peach.——*Fig.* 919. Vertical section of the flower of the Quince (*Cydonia vulgaris*).

Distribution, &c.—Natives of the East Indies and Arabia. There is only one genus (*Moringa*), and 4 species.

Properties and Uses.—Pungent and slightly aromatic properties more or less prevail in plants of the order, hence they have been employed as stimulants.

Moringa pterygosperma.—The root resembles that of Horse-radish in its taste and odour, and has been used as a stimulant and rubefacient. A kind of gum somewhat resembling Tragacanth exudes from the bark when wounded. Its seeds are called in France *Pois Quéniques* and *Chicot*, and in England Ben-nuts. They yield a fixed oil called Oil of Ben, which is sometimes used by painters, and also by perfumers and match-makers.

Natural Order 82. Rosaceæ.—The Rose Order.—General Character.—*Trees, shrubs*, or *herbs*. *Leaves* simple (*fig*. 288), or compound (*fig*. 355), alternate (*fig*. 266), usually stipulate (*figs*. 288 and 355). *Flowers* regular, generally hermaphrodite (*figs*. 916—919), rarely unisexual. Calyx monosepalous (*figs*, 462 and 917), with a disk either lining the tube or surrounding the orifice, 4- or 5-lobed, when 5, the odd lobe posterior (*fig*. 916), sometimes surrounded by a whorl of bracts forming an involucre or epicalyx (*fig*. 441). *Petals* 5 (*figs*. 462 *p*. and 916), perigynous, rarely none (*fig*. 921). *Stamens* definite (*fig*. 921), or numerous, perigynous (*figs*. 916—918); *anthers* (*fig*. 920) 2-celled, innate, dehiscing longitudinally *Ovaries* 1 (*fig*. 921), 2 (*fig*. 532), 5, or numerous (*figs*. 916 and 917); 1-celled (*figs*. 921—924), usually apocarpous and superior (*figs*. 916, 917) ; or sometimes more or less combined together, and with the tube of the calyx, and thus becoming inferior (*fig*. 919); *styles* basilar (*figs*. 624 and 921), lateral (*fig*. 623), or terminal (*fig*. 918) ; *ovules* 1 (*figs*. 923 and 924), or few (*fig*. 919). *Fruit* various, either a drupe (*figs*. 677 and 678), an achænium (*fig*. 921), a follicle, a dry or succulent etærio (*figs*. 591 and 645), a cynarrhodum (*fig*. 439), or a pome (*figs*. 459 and 702). *Seeds* 1 or few, exalbuminous; *embryo* (*fig*. 922), straight, with flat cotyledons.

Diagnosis.—Trees, shrubs, or herbs, with alternate leaves

Fig. 921. *Fig*. 920. *Fig*. 924.

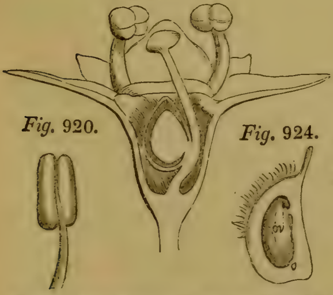


Fig. 923.

Fig. 922.

Fig. 920. Anther with part of the filament of a species of *Rubus*.——*Fig*. 921. Vertical section of the flower of *Alchemilla*.——*Fig*. 922. Vertical section of the fruit of the Cherry (*Cerasus*). *ep*. Epicarp. *me*. Mesocarp. *en*. Endocarp, within which is the seed and embryo.——*Fig*. 923. Vertical section of an achænium of the Rose.——*Fig*. 924. Vertical section of the ovary *o*, of a species of *Rubus*, with the ovule, *ov*.

Flowers regular. Calyx 4—5-lobed; when 5, the odd lobe posterior. Petals 5 or none. Stamens perigynous, distinct ; anthers 2-celled. Carpels one or more, usually distinct, or some-

times united, generally superior, or occasionally more or less inferior. Seeds 1 or few, exalbuminous; embryo straight.

Division of the Order, &c.— The order Rosaceæ as above defined, may be divided into five sub-orders, which are by some botanists considered as distinct orders. They are as follows: —

Sub-order 1. *Chrysobalaneæ.* — *Trees* or *shrubs*, with simple leaves, and free stipules. Carpel solitary, cohering more or less on one side with the calyx; ovules 2, erect; style basilar. Fruit a drupe. Seed erect. *Examples:* Chrysobalanus, Moquilea.

Sub-order 2. *Amygdaleæ* or *Drupaceæ.*—*Trees* or *shrubs*, with simple leaves, and free stipules. Calyx deciduous. Carpel solitary, not adherent to the calyx; style terminal. Fruit a drupe. Seed suspended. *Examples:* Amygdalus, Prunus, Cerasus.

Sub-order 3. *Roseæ.*—*Shrubs* or *herbs*, with simple or compound leaves, and adherent stipules. Carpels 1 or more, superior, not united to the tube of the calyx, distinct, or sometimes more or less coherent; styles lateral, or nearly terminal. Fruit either an etærio, or consisting of several follicles. Seed usually suspended, or rarely ascending. *Examples:* Rosa, Rubus, Fragaria, Spiræa, Brayera, Quillaia, Lindleya, Neurada.

Sub-order 4. *Sanguisorbeæ.*— *Herbs* or *undershrubs.* Flowers often unisexual. Petals frequently absent. Carpel solitary; style terminal or lateral. Fruit an achænium inclosed in the tube of the calyx, which is often indurated. Seed solitary, suspended or ascending. *Examples:* Alchemilla, Sanguisorba, Poterium.

Sub-order 5. *Pomeæ.*—*Trees* or *shrubs*, with simple or compound leaves, and free stipules. Carpels 1 to 5, adhering more or less to each other and to the sides of the calyx, and thus becoming inferior; styles terminal. Fruit a pome, 1—5-celled, or rarely spuriously 10-celled. Seeds ascending. *Examples:* — Cydonia, Pyrus, Mespilus, Cotoneaster, Cratægus.

Distribution, &c.—The *Chrysobalaneæ* are principally natives of the tropical parts of America and Africa. The *Amygdaleæ* are almost exclusively found in the cold and temperate regions of the northern hemisphere. The *Roseæ* and *Sanguisorbeæ* are also chiefly natives of cold and temperate climates, although a few are found within the tropics. The *Pomeæ* occur only in the cold and temperate regions of the northern hemisphere. The order Rosaceæ comprises about 90 genera, and 1000 species, of which about one half belong to the sub-order Roseæ.

Properties and Uses.—The plants of the order are principally remarkable for their astringency, and for their succulent edible fruits. The seeds, flowers, leaves, and young shoots of many of

the *Amygdaleæ* and *Pomeæ*, when moistened with water yield Hydrocyanic acid; hence the parts of such plants are sometimes poisonous. All other Rosaceæ are entirely devoid of any poisonous properties.

Sub-Order 1. CHRYSOBALANEÆ.—Many plants of this sub-order produce edible drupaceous fruits. Thus, that of

Chrysobalanus Icaco is known in the West Indies under the name of the Cocoa-plum, and that of *C. luteus* is eaten in Sierra Leone. The root, bark, and leaves of *C. Icaco* are employed in Brazil as a remedy in diarrhœa and similar diseases.

Parinarium excelsum also yields an edible fruit, which is known in Sierra Leone under the name of the Rough-skinned or Gray Plum. The kernels of *P. campestre* and *montanum* are also reputed to resemble the Almond in flavour.

Sub-Order 2. AMYGDALEÆ or DRUPACEÆ.—This sub-order is remarkable from the parts of many of its plants yielding when moistened with water, hydrocyanic acid. Their barks also frequently possess astringent and febrifugal properties, and yield a kind of gum: while many again, have edible fruits and seeds.

Amygdalus communis is the Almond-tree, of which there are two varieties, namely, the *A. communis*, var. *dulcis*, and the *A. communis*, var. *amara*. The seeds of the former are known as Sweet Almonds; those of the latter, as Bitter Almonds. The Almond-tree is a native of Syria and many other parts of Asia, and also of Barbary and Northern Africa; it is also extensively cultivated in the southern parts of Europe. Sweet Almonds yield by expression a fixed oil commonly known as Oil of Almonds. They also contain sugar, gum, and a substance called vegetable albumen, Synaptase, or Emulsin. The cake left after the expression of the oil, when dried and powdered, is known under the name of Almond-powder. Bitter Almonds yield a similar oil by expression. They also contain Emulsin, and in addition to the other ordinary constituents of Sweet Almonds, a nitrogenous substance called Amygdaline. When bitter almonds are moistened with water, the Emulsin and Amygdaline mutually react upon each other and form a volatile oil containing hydrocyanic acid, and which is known as the Essential Oil of Bitter Almonds. The presence of hydrocyanic acid renders this oil very poisonous, but this is not the case when the acid is separated from it: this may be done by distilling it with a mixture of protochloride of iron, peroxide of mercury, lime, and water. Bitter Almonds and their essential oil are extensively employed for flavouring by the cook and confectioner, and also for scenting soap and for other purposes by the perfumer. The cake left after expressing the oil is frequently used for fattening pigs and for other purposes. *A. persica* is the Peach-tree of our gardens, and a variety of the same species produces the Nectarine. The flowers of *A. persica* have been employed as a vermifuge, and the leaves for flavouring, and as a vermifuge. The kernels may be used for the same purposes as the Bitter Almond. All these parts, as well as the bark, possess poisonous properties owing to the formation of hydrocyanic acid.

Prunus domestica and its varieties produce the well-known fruits called Plums, Greengages, and Damsons. When dried plums are termed Prunes or French Plums. *P. spinosa* is the common Sloe or Blackthorn, and *P. institia*, the Bullace. *P. Armeniaca* is the Apricot. The barks of *P. spinosa* and *Coccomilia* have febrifugal properties. The leaves of *P. spinosa* are sometimes used for adulterating the black tea of China. A mixture consisting of the leaves of *P. spinosa* and those of *Fragaria collina*, or *F. vesca*, in the proportion of one-third of the former to two-thirds of the latter, are said to form a good substitute for China Tea.

Cerasus.—Several species or varieties of this genus produce the fruits called Cherries: thus, *C. serotina* is the Black Cherry: *C. avium* the Wild Cherry; *C. Padus* the Bird Cherry; and *C. virginiana* the Choke Cherry or Choke-berry. The latter is one of the fruits which is commonly mixed with Pemican. (See *Amelanchier*, p. 536). Some species have astringent and febrifugal properties, as the barks of *C. virginiana*, *Capollim*, *capricida*, &c. The leaves, bark, and fruit of the *Cerasus Lauro-cerasus*, the Common Laurel or Cherry-laurel, are poisonous. Their poisonous properties are due to the production of a volatile oil containing hydrocyanic acid when they are moistened with water. Cherry-laurel water is anodyne and sedative in its action, and may be employed

in all cases where hydrocyanic acid has been used. It is, however, very liable to vary in its strength. It is commonly prepared by the distillation of the leaves with water. *C. lusitanica* is the Portugal Laurel of our shrubberies. The kernels of *C. occidentalis* and other species are used for flavouring liqueurs, as Noyeau, Cherry-brandy, Maraschino, &c. A gummy exudation somewhat resembling tragacanth takes place more or less from the stems of the different species of *Cerasus*.

Sub-Order 3.—ROSEÆ. The Roseæ are chiefly remarkable for their astringent properties.

Rosa.—The various species and varieties of this genus are well known for the beauty of their flowers and for their delicious odours. The fruit (commonly known under the name of the hip) of *R. canina*, the Dog-Rose, is employed in medicine as a refrigerant and astringent. The dried petals of the unexpanded flowers of *R. gallica* constitute the *red-rose leaves* of the shops. They are used in medicine as mild astringents and tonics. The flowers when full blown are slightly laxative. The petals of *R. centifolia*, the Hundred-leaved or Cabbage-rose, and of some of its varieties, are remarkable for their fragrancy. Rose water is prepared by distilling the fresh petals with water to which a little spirit of wine has been added. From the petals of *R. centifolia*, *R. moschata*, and *R. Damascena*, the volatile oil known as *Attar* or *Otto of Roses* is obtained. This may be procured either by distillation, or by macerating the petals in water and exposing the mixture to the sun, when the oil floats out. Heber says, that it requires 20,000 roses to yield attar equal in weight to that of a rupee. This quantity is worth about ten pounds. It is imported from Smyrna and Constantinople. Otto of Roses is rarely or ever pure when imported into this country. It is commonly adulterated with spermaceti, and a volatile oil which appears to be derived from one or more species of *Andropagon* (see *Andropagon*), and which is called in London, Oil of Ginger-grass, or Geranium. The petals of *R. centifolia* are also employed in medicine as a mild laxative.

Rubus. — Several species of this genus yield edible fruits: thus, the fruit of *Rubus Idæus* is the Raspberry; that of *R. fruticosus*, the Blackberry; that of *R. cæsius*, the Dewberry; and that of *R. Chamæmorus*, the Cloudberry. The root of *R. villosus* is much employed as an astringent in some parts of North America.

Fragaria elatior, *vesca*, *&c*, furnish the different kinds of Strawberries.

Potentilla Tormentilla.—The rhizome and root possess astringent and tonic properties. They are employed in the Orkney and Feroe Islands to tan leather; and in Lapland in the preparation of a red dye. Many other species possess somewhat analogous properties.

Agrimonia Eupatoria, has been used as a vermifuge and astringent.

Geum urbanum and *rivale* are reputed to possess aromatic, tonic, and astringent properties. The root of *G. urbanum* was at one time officinal in the Dublin Pharmacopœia.

Spiræa filipendula and *Ulmaria.* — The roots of these plants have tonic properties. *S. Ulmaria* is called Meadow-sweet from the fragrance of its flowers. Seemann says, that in Kamtschatka, a strong liquor is prepared from the root of *S. Kamtschatka*.

Gillenia trifoliata and *stipulacea.*—The roots of both these species are used in the United States as medicinal agents. In small doses they are tonic, and in larger doses emetic. They are commonly known under the names of Indian physic, and American Ipecacuanha.

Brayera anthelmintica is a native of Abyssinia. It is called Kosso or Koussoo. The flowers and other parts of the plant have been long employed by the Abyssinians for their anthelmintic properties. They have been also used of late years in this and other countries for a similar purpose, and in some instances with great success.

Quillaia saponaria.—The bark of this and other species contain a large amount of *saponine*. It is employed in some parts of America as a substitute for soap. It has been also much used in this country lately as a detergent, in cases of scurfiness and baldness of the head.

Sub-Order 4.—SANGUISORBEÆ.—The plants of this sub-order have generally astringent properties like the *Roseæ*.

Alchemilla arvensis, Field Ladies' Mantle or Parsley Piert, is astringent and tonic. It is also reputed to be diuretic, and was formerly thought to be useful in gravel and stone: hence it was called *break-stone*.

Acæna Sanguisorba. — The leaves are used in New Holland as a substitute for tea.

Sub-Order 5. POMEÆ. — Many plants of this sub-order yield edible fruits, and from their seeds hydrocyanic acid may be frequently obtained. The flowers of several are celebrated for their beauty.

Cydonia vulgaris, the Common Quince. — The fruit is frequently mixed with apples in making pies or tarts, and is much esteemed for the preparation of a kind of marmalade and for other purposes by the confectioner. In the rind, œnanthic ether has been found by Wohler, to which its peculiar fragrance is due. The seeds contain much mucilage, which is nutritive, emollient, and demulcent. The seeds are said to yield hydrocyanic acid.

Pyrus.—Some species of this genus produce edible fruits. *Pyrus Malus* and its varieties produce the different kinds of Apples. *P. communis* is the Pear-Tree. The wood of the latter is sometimes used by wood-engravers instead of box. *P. Aucuparia* is the Mountain Ash or Rowan-Tree. Its flowers, root, and bark, yield hydrocyanic acid, and therefore, probably possess sedative properties. *P. Aria* is the Beam Tree, the timber of which is used for axle-trees and other purposes. *P. domestica* is the Service Tree, and *P. torminalis* the Wild Service Tree.

Mespilus germanica yields the fruit called the Medlar, of which there are several varieties.

Amelanchier canadensis.—The fruit is known in Rupert's Land, &c., under the name of Shad-berry or Service-berry. It is used for mixing with Pemican, an article of Arctic diet. (See p. 535. *Cerasus*.)

Eriobotrya japonica produces a fruit called the Loquat.

Cratægus Oxyacantha is the Whitethorn or Hawthorn Tree, so well known for the beauty of its flowers, &c. In some places the name of *May* is given to it, from its usually flowering in that month.

Natural Order 83. CALYCANTHACEÆ. — The Calycanthus Order.—*Diagnosis*.—These are shrubby plants resembling the *Rosaceæ*, but they differ in having opposite leaves, which are always simple, entire, and exstipulate; in their sepals and petals being numerous, and similar in appearance; in having stamens whose anthers are adnate, and turned outwards; and by having convolute cotyledons.

Distribution, &c.—They are natives of Japan and North America. *Examples*:—Calycanthus, Chimonanthus. These are the only 2 genera, which include 6 species.

Properties and Uses.—The flowers are fragrant and aromatic. The bark of *Calycanthus floridus*, Carolina Allspice, is sometimes used in the United States as a substitute for Cinnamon bark.

Natural Order 84. LYTHRACEÆ.—The Loosestrife Order.—General Character.—*Herbs* or rarely shrubs, frequently 4-sided. *Leaves* opposite, or rarely alternate, entire and exstipulate. *Flowers* regular or irregular. *Calyx* (*fig.* 926) persistent, ribbed, tubular below, the lobes with a valvate or distant æstivation, sometimes with intermediate teeth (*fig.* 926). *Petals* inserted between the lobes of the calyx and alternate with them (*fig.* 925), sometimes wanting, very deciduous. *Stamens* perigynous, inserted below the petals (*fig.* 925), to which they are equal in number, or twice as many, or even more numerous; *anthers* adnate, 2-celled (*fig.* 925), opening longitudinally. *Ovary* superior (*fig.* 925), 1, 2, or 6-celled; *ovules* numerous, or rarely few; *style* 1, filiform (*fig.* 925); *stigma* capitate, or rarely 2-lobed. Fruit capsular, membranous, dehiscent, surrounded by the non-adherent calyx. *Seeds* numerous, with or without

wings, exalbuminous; placentation axile (*fig.* 925); *embryo* straight, with flat leafy cotyledons, and the radicle towards the hilum.

Fig. 925.

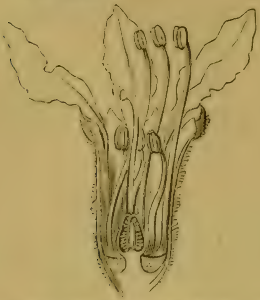


Fig. 926.

Fig. 925. Vertical section of the flower of Purple Loosestrife (*Lythrum Salicaria*).——*Fig.* 926. Calyx of the same.

Diagnosis. — Herbs or shrubs, with entire, exstipulate, and usually opposite leaves. Calyx tubular, ribbed, persistent, bearing the deciduous petals and stamens; the latter being inserted below the petals. Anthers 2-celled, adnate, bursting longitudinally. Ovary superior, with axile placentation; style 1. Fruit membranous, dehiscent, surrounded by the non-adherent calyx. Seeds numerous, exalbuminous.

Distribution, &c.—The greater number are tropical plants, but some are also found in temperate regions, as, for instance, in Europe and North America. One species only, *Lythrum Salicaria*, has been hitherto found in New Holland. *Examples:* — Peplis, Lythrum, Cuphea, Lawsonia, Physocalymma, Lagerströmia. There are 35 known genera, and about 300 species.

Properties and Uses. — The plants of the order are chiefly remarkable for the possession of an astringent principle, and for their use in dyeing.

Lythrum Salicaria, Purple Loosestrife, is a common British plant, and is said to be useful as an astringent in diarrhœa, &c. Other species probably possess similar properties.

Cuphea.—Many species of this genus are cultivated for the beauty of their flowers. They are remarkable for the curious manner in which the placenta bursts through its coverings, and by so doing forms an external process upon which the seeds are borne.

Grislea tomentosa.—In India, the flowers are employed in dyeing, mixed with species of Morinda (*Cinchonaceæ*). (See *Morinda.*)

Lawsonia inermis is the plant from which the Henna or Alkanna of Egypt &c., is derived. It is used by the women in the East to dye the nails, palms of the hand, and soles of the feet, of an orange-brown colour. It is likewise employed for dyeing skins and morocco leather reddish-yellow.

Lagerströmia Regina has narcotic seeds, and its leaves and bark are reputed to be purgative and hydragogue.

Natural Order 85. SAXIFRAGACEÆ.—The Saxifrage Order.—General Character.—*Herbs* with alternate leaves (*fig*. 927), which are entire or lobed, stipulate or exstipulate. *Calyx* of 4 or 5 sepals more or less united at the base (*figs*. 610 and 928), inferior, or more or less superior (*figs*. 610 and 928). *Petals* 4 or 5, perigynous, alternate with the lobes of the calyx (*fig*. 928), sometimes wanting. *Stamens* 5—10, perigynous (*fig*. 928) or hypogynous; *anthers* 2-celled, with longitudinal dehiscence. *Disk* usually evident, and either existing in the form of 5 scaly processes, or annular and notched, hypogynous or perigynous. *Ovary* superior, or more or less inferior (*figs*. 610 and 928), usually composed of 2 carpels, coherent below, but more or less distinct towards the apex; 1 or 2-celled; *styles* equal in number to the carpels, distinct, diverging. *Fruit* capsular, 1—2-celled, usually membranous. *Seeds* small, numerous (*fig*. 928); *embryo*

Fig. 927.

Fig. 928.

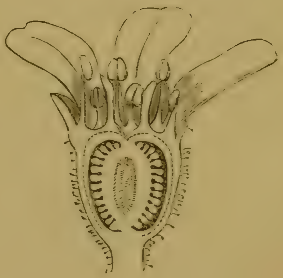


Fig. 929.

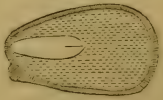


Fig. 927. *Saxifraga tridactylites*. The leaves are trifid and wedge-shaped, and the flowers arranged in a racemose cyme.——*Fig*. 928. Vertical section of the flower.——*Fig*. 929. Vertical section of the seed.

(*fig*. 929) in the axis of fleshy albumen, with the radicle towards the hilum.

Diagnosis.—Herbs with alternate leaves. Flowers unsym-

metrical. Calyx inferior, or generally more or less superior, 4—5-parted. Stamens perigynous or hypogynous. Ovary superior, or more or less inferior, composed of 2 carpels united at the base, and diverging at the apex ; styles distinct, equal in number to the carpels. Fruit capsular, 1—2-celled. Seeds numerous, small, with fleshy albumen.

Distribution, &c.—They are exclusively natives of the northern parts of the world, where they chiefly inhabit mountainous districts, and sometimes grow as high as 16,000 feet above the level of the sea. *Examples:*—Vahlia, Saxifraga, Chrysosplenium, Heuchera. There are 19 genera, and 310 species.

Properties and Uses.—The plants of the order are all more or less astringent. This is remarkably the case with the root of *Heuchera americana*, which is much used for its astringent properties in the United States under the name of *Alum-root.*

Natural Order 86. HYDRANGEACEÆ.—The Hydrangea Order —*Diagnosis.*—This order is frequently regarded as a sub-order of Saxifragaceæ, with which it agrees in many important particulars ; but it differs in the plants belonging to it being of a shrubby nature ; in their having opposite leaves, which are always exstipulate; in their tendency to a polygamous structure as exhibited in the possession of radiant staminal flowers ; and in having frequently more than 2 carpels with a corresponding increase in the number of styles and cells to the ovary.

Distribution, &c.—Natives chiefly of the temperate regions of Asia and America. About one-half of the species are natives of China and Japan. *Examples:*—Hydrangea, Platycrater, Bauera. There are 9 genera, and 45 species.

Properties and Uses.—Unimportant. The leaves of *Hydrangea Thunbergii* are used in Japan as tea, and this tea is so highly valued by the Japanese, that they call it *Ama-tsjâ* or the Tea of Heaven. The Hydrangeas are familiar cultivated plants. The root of *H. arborescens*, under the name of *Leven Bark* or *Wild Hydrangea*, is largely employed in some parts of North America in calculous complaints.

Natural Order 87. HENSLOVIACEÆ.—The Henslovia Order.—*Diagnosis.*—This is a small order of tropical plants containing but 1 genus, and 3 or 4 species, which is considered by Lindley to be nearly allied to Hydrangeaceæ. The chief differences being in their tree-like habit; in their styles being united into a cylinder, and in the total absence of albumen. *Example:*—Henslovia. Their properties and uses are unknown.

Natural Order 88. CUNONIACEÆ.—The Cunonia Order.—*Diagnosis.*—Nearly allied to Saxifragaceæ, but differing from them in being trees or shrubs, with opposite leaves, and large interpetiolar stipules. The latter character will also distinguish them readily from Hydrangeaceæ, which are exstipulate.

Distribution, &c.—Natives of South America, the Cape, the

East Indies, and Australia. *Examples:*—Weinmannia, Cunonia, Raleighia. There are 22 genera, and 100 species.

Properties and Uses.—Astringent. Some have been used for tanning; others exude a gummy secretion.

Natural Order 89. CRASSULACEÆ.—The Houseleek or Stonecrop Order.—General Character.—Succulent herbs or shrubs. *Leaves* entire or pinnatifid, exstipulate. *Flowers* usually cymose (*fig.* 413), symmetrical (*figs.* 763 and 764). *Calyx* generally composed of 5 sepals, but varying in number from 3—20, more or less combined at the base, inferior (*fig.* 763), persistent. *Petals* equal in number to the divisions of the calyx (*fig.* 763, *p*), with which they are alternate, either distinct or cohering, and inserted into the bottom of the calyx; *æstivation* imbricated. *Stamens* inserted with the petals (*fig.* 763, *e*), either equal to them in number and alternate with them (*fig.* 763), or twice as many (*fig.* 764), and then forming 2 whorls, one of which is composed of longer stamens than the other; the longer stamens are placed alternate to the petals, and the shorter stamens opposite to them; *anthers* 2-celled with longitudinal dehiscence. *Carpels* equal in number to the petals and opposite to them (*fig.* 763, *o*, *o*), each having frequently a scale on the outside at the base (*fig.* 763, *a*), distinct or more or less united; *styles* distinct. *Fruit* either consisting of a whorl of follicles (*fig.* 566), or a capsule with loculicidal dehiscence. *Seeds* very small, variable in number; *embryo* in the axis of fleshy albumen, with the radicle towards the hilum.

Diagnosis.—Succulent herbs or shrubs. Leaves exstipulate. Flowers perfectly symmetrical, the sepals, petals, and carpels being equal in number (3—20), and the stamens being also equal to them, or twice as many. Petals and stamens almost, or quite hypogynous. Corolla monopetalous or polypetalous. Fruit either apocarpous and follicular, or a many-celled capsule with loculicidal dehiscence. Seeds small; *embryo* in the axis of fleshy albumen.

Division of the Order, &c.—The order has been divided into two sub-orders as follows:—

Sub-order 1. *Crassuleæ.*—Fruit consisting of a whorl of follicles. *Examples:*—Crassula, Bryophyllum, Cotyledon, Echeveria, Sedum.

Sub-order 2. *Diamorpheæ.*—Fruit a many-celled capsule with loculicidal dehiscence. *Examples:*—Diamorpha, Penthorum.

Distribution, &c.—They are found in very dry situations in all parts of the world; a large number occur at the Cape of Good Hope. There are 25 genera, and 450 species.

Properties and Uses.—Astringent, refrigerant, and acrid properties are found in the plants of this order, but they are generally unimportant.

Cotyledon umbilicus.—This plant, which is a common native in the West of England, has long been in use as a popular remedy in hysteria, and as an external application to destroy corns and warts. It has been frequently used of late years as a remedy for epilepsy. *C. orbiculata*, a native of the Cape of Good Hope, is employed in similar cases.

Sedum acre is the common yellow Biting Stonecrop of our walls, and as its name implies, it is of an acrid nature. It is also reputed to possess emetic and purgative properties. *Sedum Telephium* is astringent. Lindley says, that in Ireland, the leaves of *Sedum dasyphyllum*, rubbed among oats, are regarded as a certain cure for worms in horses.

Rhodiola esculenta is eaten by the Greenlanders.

Natural Order 90. FRANCOACEÆ. — The Francoa Order. — Stemless herbs. *Leaves* exstipulate. *Calyx* 4-partite. *Petals* 4, persistent. *Stamens* hypogynous, or nearly so, four times as many as the petals, the alternate ones sterile. *Ovary* superior, 4-celled; *ovules* numerous; *stigma* 4-lobed; *style* none. *Fruit* a membranous 4-celled, 4-valved capsule, with loculicidal or septicidal dehiscence. *Seeds* minute, indefinite; *embryo* very minute, at the base of a large quantity of fleshy albumen.

Distribution, &c.—Natives of Chili. There are but 2 genera, and 5 species. *Examples:* — Francoa, Tetilla.

Properties and Uses. — The *Francoas* are reputed to be cooling and sedative. *Tetilla* is astringent, and is employed as a remedy for dysentery.

Natural Order 91. PARONYCHIACEÆ or ILLECEBRACEÆ. — The Knotwort Order. — *Herbs* or *shrubs*, with entire, simple, stipulate leaves. *Flowers* minute. *Sepals* 5, or rarely 3 or 4, distinct, or more or less coherent. *Petals* small, or absent, perigynous. *Stamens* somewhat hypogynous, either equal in number to the sepals and opposite to them, or more numerous, or rarely fewer. *Ovary* superior, 1 or 3-celled; *styles* 2—5. Fruit dry, 1 or 3-celled, dehiscent or indehiscent. *Seeds* either numerous upon a free central placenta, or solitary on a long funiculus arising from the base of the fruit; *albumen* farinaceous; *embryo* curved.

Distribution, &c. — Natives chiefly of barren places in the south of Europe and the north of Africa. *Examples:* — Corrigiola, Herniaria, Polycarpon, Spergula. There are 24 genera, and about 100 species.

Properties and Uses. — Slightly astringent, but none of the plants are of any particular importance.

Natural Order 92. PORTULACACEÆ. — The Purslane Order. — Succulent *herbs or shrubs*, with entire exstipulate leaves. *Flowers* unsymmetrical. *Sepals* 2, coherent at the base. *Petals* usually 5, distinct or united. *Stamens* perigynous or hypogynous, varying in number, sometimes opposite to the petals; filaments distinct; *anthers* 2-celled, versatile. *Ovary* superior, or rarely partially adherent. *Fruit* capsular, usually dehiscing transversely, or by valves; sometimes indehiscent; *placenta* free central. *Seeds* numerous or solitary; *embryo* curved round farinaceous albumen.

Distribution, &c.—Natives of waste dry places in various parts of the world, but chiefly at the Cape of Good Hope and in South America. *Examples*:—Portulaca, Talinum, Claytonia, Montia. There are 12 genera, and 184 species.

Properties and Uses.—The fleshy root of *Claytonia tuberosa* is edible. *Portulaca oleracea* has been used from the earliest times as a pot-herb, and in salads. It possesses cooling and antiscorbutic properties. Many of the plants have large showy flowers.

Natural Order 93. MESEMBRYACEÆ or FICOIDEÆ.—The Ice-Plant or Fig-Marigold Order.—General Character.—Succulent herbs or shrubs, with opposite or alternate, simple leaves. *Calyx* 3—8-partite, either free, or partially adherent to the ovary. *Petals* either numerous and showy, or altogether absent. *Stamens* perigynous, distinct, numerous or definite. *Ovary* inferior or nearly superior, usually many-celled, rarely 1-celled; *placentas* axile, free central, or parietal; *styles* and *stigmas* as many as the cells of the ovary, distinct; *ovules* usually numerous, or rarely solitary, amphitropal or anatropal. Fruit usually a many-celled capsule, or rarely 1-celled, dehiscing in a stellate or circumscissile manner at the apex, or splitting at the base, or woody and indehiscent. *Seeds* few or numerous, or rarely solitary; *embryo* curved or spiral, on the outside of mealy albumen.

Diagnosis.—Succulent herbs or shrubs, with simple exstipulate leaves. Sepals definite, generally more or less united to the ovary. Petals very numerous, or absent. Stamens perigynous. Ovary inferior or nearly superior; styles distinct; placentas axile, free central, or parietal. Fruit capsular, or indehiscent. Seeds with a curved or spiral embryo on the outside of mealy albumen.

Division of the Order, &c.—The Mesembryaceæ may be divided into three sub-orders as follows:—

Sub-order 1. *Mesembryeæ.*—Leaves opposite. Petals numerous, conspicuous. Stamens numerous. Fruit capsular, dehiscent. *Examples*:—Mesembryanthemum, Glinus, Lewisia.

Sub-order 2. *Tetragoneæ.*—Leaves alternate. Petals absent. Stamens definite. Fruit woody and indehiscent. *Examples*:—Tetragonia, Aizoon.

Sub-order 3. *Sesuveæ.*—Leaves alternate. Petals absent. Stamens definite. Fruit capsular, with transverse dehiscence. *Examples*:—Sesuvium, Cypsela.

The two last sub-orders are commonly placed in one order, called *Tetragoniaceæ*, which is then readily distinguished from the Mesembryaceæ, by its plants having alternate leaves, no petals, and but a small number of stamens. The plants comprehended in the above three sub-orders are, however, so nearly allied, that I have placed them in one order as above.

Distribution, &c.—Natives exclusively of warm and tropical

regions. A large number are found at the Cape of Good Hope. There are 16 genera, and 440 species.

Properties and Uses. — Several are edible; others yield an abundance of soda when burned, but generally the plants of the order are of little importance.

Mesembryanthemum crystallinum is the Ice-plant. It is so called from its surface being studded with little watery vesicles of an ice-like appearance. Its juice is reputed to be diuretic. The ashes of this species, as well as those of *M. copticum*, *nodiflorum*, and others, contain soda. *M. geniculiflorum* is employed as a pot-herb in Africa, and its seeds are edible. *M. edule* is called the Hottentot's-Fig; its leaves are eaten. The fruit of *M. æquilaterale* (Pig-faces, or Canagong), is eaten in Australia.

Lewisia rediviva.— The root is eaten in Oregon. It is sometimes called Tobacco-root from the smell of tobacco which it is said to acquire by cooking. According to M. Geyer, it is the *Racine amère* of the Canadian Voyageurs; it forms a very agreeable and wholesome food when cooked.

Tetragonia expansa is used in New Zealand as a substitute for spinage. It has been cultivated in Europe, and employed for the same purpose under the name of New Zealand Spinage.

Natural Order 94. PASSIFLORACEÆ. — The Passion-Flower Order. — Herbs or shrubs, usually climbing by tendrils (*fig.* 209). *Leaves* alternate, with foliaceous stipules. *Flowers* perfect, or very rarely unisexual. Sepals 5, united below into a tube, the throat of which bears a number of filamentous processes; *petals* 5, inserted in the throat of the calyx on the outside of the filamentous processes, with an imbricated æstivation; sometimes wanting. *Stamens* usually 5, monadelphous, rarely numerous, surrounding the stalk of the ovary. *Ovary* stalked, superior, 1-celled; *styles* 3, clavate; *placentas* parietal. *Fruit* 1-celled, stalked, generally succulent. *Seeds* numerous, arillate; *embryo* in thin fleshy albumen.

Distribution, &c.—They are chiefly found in tropical America, but a few also occur in North America and the East Indies, and several in Africa. *Examples:* — Paropsis, Passiflora, Tacsonia, Barteria. There are 13 genera, and 211 species.

Properties and Uses. —Many are cultivated for the beauty of their flowers and foliage. Several have edible fruits, and others are said to be bitter and astringent, narcotic, emmenagogue, or diaphoretic.

Paropsis edulis has an edible fruit. It is a native of Madagascar.

Passiflora.—The fruits of several species of this genus are eaten under the name of Granadillas. The root of *P. quadrangularis* is said to be narcotic. The flowers of *P. rubra* are also narcotic. Other species are reputed to be anthelmintic, emmenagogue, emetic, carminative, &c.

Tacsonia.—The pulpy fruits of *T. speciosa*, *mollissima*, *tripartita*, and others, are edible.

Natural Order 95. MALASHERBIACEÆ. — The Crownwort Order. —*Diagnosis.* — This is a small order of herbaceous, or somewhat shrubby plants, resembling *Passifloraceæ*, but differing in never being climbers; in the want of stipules; in the filamentous processes of that order being reduced to a short membranous rim or coronet in this; in the insertion of their

styles at the back instead of the apex of the ovary; and in the seeds not being arillate.

Distribution, &c. — They are all natives of Chili and Peru. *Examples:* — Malasherbia, Gynopleura. These are the only genera, which include but 5 species.

Properties and Uses. — Altogether unknown.

Natural Order 96. TURNERACEÆ. — The Turnera Order. — Herbaceous or somewhat shrubby plants. *Leaves* alternate, exstipulate, hairy. *Flowers* axillary. *Calyx* inferior, 5-lobed, imbricated in æstivation. *Petals* 5, equal, twisted in æstivation, perigynous. *Stamens* 5, alternate with the petals, perigynous; *filaments* distinct. *Ovary* 1-celled, superior, with 3 parietal placentas; *styles* 3, more or less coherent at the base, and undivided, or forked, or branched above. *Fruit* capsular, 1-celled, 3-valved, partially dehiscing in a loculicidal manner. *Seeds* with a strophiole on one side, with a slightly curved embryo in the midst of fleshy albumen.

Distribution, &c. — Natives exclusively of South America and the West Indies. *Examples:* — Turnera, Piriqueta. These are the only genera according to Lindley; they include about 60 species.

Properties and Uses. — Some are said to be astringent, others tonic and expectorant, and a few aromatic.

Natural Order 97. PAPAYACEÆ. — The Papaw Order. — Trees or shrubs, sometimes with an acrid milky juice. *Leaves* alternate, on long stalks, lobed. Flowers unisexual. *Calyx* inferior, minute, 5-toothed. *Corolla* monopetalous, without scales in the fertile flowers, 5-lobed. The *barren flower* has a few stamens inserted on the corolla. The *fertile flower* has a 1-celled superior ovary, with 3—5 parietal placentas. *Fruit* succulent, or dehiscent. *Seeds* numerous, albuminous, with the radicle towards the hilum.

Distribution, &c. — Natives of South America and of the warmer parts of the Old World. *Examples:* — Carica, Modecca. There are 8 genera, and 25 species.

Properties and Uses.—The acrid milky juice of *Carica digitata* is said to be a deadly poison. The juice of the unripe fruit, and the powdered seeds of *Carica Papaya* are powerful anthelmintics. The fruit, however, when cooked, is eaten. This plant is said to have the property of rendering meat tender. It is stated that newly-killed meat hung among the leaves soon becomes tender, and even that the flesh of old hogs and old poultry fed on its leaves or fruit becomes tender. The leaves are also used in some districts as a substitute for soap. The juice according to Vauquelin, is a highly animalised substance, resembling animal albumen in its characters and reactions.

Natural Order 98. PANGIACEÆ. — The Pangium Order. — *Diagnosis.*—This is a small order of arborescent unisexual plants nearly allied to *Papayaceæ*, but differing principally in being

polypetalous; and in the fertile flowers having as many scales as there are petals, and placed opposite to them.

Distribution, &c.—Exclusively natives of the hotter parts of India. *Examples:*—Pangium, Hydnocarpus. There are 3 genera, and 4 species.

Properties and Uses.—They are all more or less poisonous. It is said, however, that by boiling, and maceration afterwards in cold water that the poisonous properties may, in some cases, be got rid of, as in the seeds of *Pangium edule*, the kernels of which are used as a condiment, and for mixing in curry, &c. Even these, however, according to Horsfield, act as a cathartic upon those unaccustomed to their use.

Hydnocarpus venenatus has a poisonous fruit, which is used in Ceylon for poisoning fish. The seeds of *H. odoratus*, termed *Chaulmoogra*, are said to be very useful in some cutaneous affections, for which purpose they are much employed in India. Other plants of the order have similar properties.

2. Epigynæ.

Natural Order 99. CUCURBITACEÆ.—The Gourd or Cucumber Order.—General Character.—Herbs, generally of a succulent nature, and either prostrate, or climbing by means of tendrils. *Leaves* succulent, alternate, with a radiate venation (*fig* 289), more or less scabrous. Flowers unisexual (*figs*. 930 and 931), monœcious or diœcious. *Calyx* monosepalous, 5-toothed (*fig*. 930), the limb sometimes obsolete, superior in the female flowers. *Corolla* monopetalous (*figs*. 930 and 931), 4—5-parted, sometimes fringed, with evident reticulated veins, perigynous. *Barren flower:*—*Stamens* usually 5, epipetalous (*fig*. 931), either distinct, or monadelphous, or triadelphous in such a way that two of the

Fig. 930.

Fig. 931.

Fig. 930. Female or pistilliferous flower of the cucumber (*Cucumis sativus*). *co.* Calyx adherent to the ovary, the limb is seen above, with five divisions. *p.* Corolla. *s.* Stigmas.——*Fig.* 931. Male or staminiferous flower of the same, the floral envelopes of which have been divided in a longitudinal manner. From Jussieu. *c.* Calyx. *p.* Corolla. *st.* Stamens.

bundles contain each 2 stamens, and the other but 1 stamen (*fig.* 931 *st*), rarely there are but 2 or 3 stamens present; *anthers* 2-celled, usually long and sinuous (*figs.* 519 *l*, and 931 *st*), rarely straight. *Fertile Flower:* — *Ovary* inferior (*fig.* 930), 1-celled, or spuriously 3-celled from the projection inwards of the placentas; *placentas* parietal (*fig.* 701 *pl*), usually 3; *ovules* indefinite, or sometimes solitary; *style* short; *stigmas* thickened, (*figs.* 634 and 930 *s*), papillose, lobed or fringed. *Fruit* a pepo (*figs.* 701 and 932), or rarely a succulent berry. *Seeds* more or less flattened, usually with a leathery or horny testa, solitary or numerous; *embryo* flat, without albumen; *cotyledons* leafy; *radicle* towards the hilum.

This order is sometimes placed amongst the corollifloræ on account of its monopetalous flowers, but its affinities are so essentially with the epigynous calycifloræ, that we have placed it here in accordance with De Candolle's views.

Diagnosis. — Herbs, usually of a succulent nature. Leaves rough, alternate, radiate-veined. Flowers unisexual. *Calyx* 5-toothed or obsolete, superior. Corolla monopetalous, perigynous. *Sterile Flower* with usually 5 stamens, which are distinct, or monadelphous, or triadelphous, epipetalous, rarely 2 or 3 stamens; anthers long, and usually sinuous. *Fertile Flower:* — Ovary inferior with parietal placentas; style short; *stigmas* more or less dilated. Fruit succulent. Seeds flat, exalbuminous; cotyledons leafy.

Fig. 932.

Fig. 932. Pepo of the Wild or Squirting Cucumber, (*Ecbalium officinarum*), discharging its seeds.

Division of the Order, &c. — This order has been divided into three sub-orders as follows: —

Sub-order 1. *Nhandirobeæ.*—Anthers not sinuous. Placentas projecting so as to meet in the centre of the fruit. Seeds numerous. *Examples:*—Telfairia, Feuillæa, Zanonia.

Sub-order 2. *Cucurbiteæ.*—Anthers sinuous. Placentas projecting so as to meet in the centre of the fruit. Seeds numerous. *Examples:* —Bryonia, Citrullus, Ecbalium, Luffa, Lagenaria, Cucumis, Cucurbita, Trichosanthes.

Sub-order 3. *Siceæ.* —Placentas not projecting. Seed solitary, pendulous. *Examples:* — Sicyos, Sechium.

Distribution, &c. — Natives principally of hot climates in almost every part of the world, but especially abundant in the East

Indies. One species occurs in the British Isles, the *Bryonia dioica.* There are about 65 genera, and more than 300 species.

Properties and Uses. — An acrid bitter purgative property is the chief characteristic of the plants of this order. This property is possessed more or less by all parts of the plant, but it is especially evident in the pulp surrounding the seeds; the seeds themselves are, however, usually harmless. In some plants this acridity is so concentrated, that they become poisonous; while in other cases, and especially from cultivation, it is so diffused that their fruit becomes edible. As a general rule the plants of this order should be regarded with suspicion.

Telfairia pedata.—The seeds of this plant yield by expression a very good oil, resembling that obtained from Olives. They have a flavour like almonds, and are eaten in Africa.

Feuillæa cordifolia has intensely bitter seeds, which are violently purgative and emetic; thus forming a striking exception to the generally harmless properties of Cucurbitaceous seeds.

Bryonia dioica.—The fresh root is sold by herbalists under the names of White Bryony and Mandrake root. (The true Mandrake root is, however, derived from *mandragora officinalis.* (See *mandragora.*) It acts violently as an emetic and purgative. In large doses it is poisonous. The root is also employed as an external application to bruised parts. The young shoots when boiled are eaten as Asparagus. *B. alba*, *americana*, and *africana*, have similar properties.

Citrullus (*Cucumis*) *Colocynthis.* The Bitter Cucumber or the Bitter Apple.—This plant is supposed to be the *wild vine* of the Old Testament, the fruit of which is translated in our version *wild gourd* (2 Kings, iv. 39). The fruit is a well-known drastic hydragogue cathartic. In large doses it is an irritant poison. It is commonly called *colocynth* or *coloquintida.* It owes its properties to a neutral bitter principle called *colocynthin.* Two kinds of colocynth are known in commerce, viz.: *Turkey or Peeled Colocynth*, which is imported from the Levant, the north of Africa, and Spain, and *Mogadore, or Unpeeled Colocynth*, which comes from Mogadore. The former is the best, and is the one generally employed in medicine; the latter being principally used by chemists for their show-bottles. The seeds possess the purgative property to a slight extent, but the pulp is by far the most active part of the fruit.

Echalium officinarum or *agreste* (*Momordica Elaterium*), is commonly called the Squirting Cucumber, from the fruit separating when ripe from its stalk, and expelling its seeds and juice with much violence (*fig.* 932). The feculence deposited from the juice of the fruit, when dried, constitutes the Elaterium, or Extract of Elaterium of the Materia Medica. In doses of from $\frac{1}{16}$ to $\frac{1}{8}$th of a grain, when pure, it is a powerful hydragogue cathartic. It owes its properties to a white crystalline, extremely bitter principle, called *Elaterin.* In improper doses Elaterium is an irritant poison.

Luffa purgans and *drastica.*—The fruit of these plants is violently purgative. It is commonly called American Colocynth. That of other species has similar properties. The fruit of *Luffa fœtida* is termed the Sponge Gourd, as it consists of a mass of fibres entangled together, and is used for cleaning guns, &c.

Lagenaria vulgaris is commonly called the Bottle Gourd, from the hard integuments of the fruit being used as a receptacle for containing fluid.

Cucumis.—The fruit of *Cucumis sativus* is the Cucumber; that of *C. Melo* is the common Melon.

Cucurbita.—The fruits of several species of this genus are employed as articles of food. Thus the fruit of *C. Citrullus* is the Water-Melon, that of *C. Pepo* is the White Gourd, that of *C. maxima* the Red Gourd or Pumpkin, and that of a variety of *C. ovifera* is the vegetable marrow. The fruit of some other species or varieties of *Cucurbita* are also eaten. An oil called *Egusé* by the inhabitants of Yorruba in Africa, and which is largely used by them for dietetic purposes, and also as a medicine, is supposed to be derived from one

or more species of *Cucurbita*. Some samples of this oil brought to this country by Dr. Daniell, have been examined by Mr. Wilson the Manager of Price's Patent Candle Company, who states that it is well adapted for burning, for the lubrication of machinery and other analogous appliances.

Trichosanthes anguinea is the Snake Gourd.—The fruits of this and other species are eaten in India mixed with curries.

Sechium edule.—The green fruit is commonly eaten in hot countries. It is called Chocho or Chacha.

Natural Order 100. Loasaceæ. — The Chili-Nettle Order. — Herbaceous plants, with stiff hairs, which are sometimes stinging. *Leaves* without stipules. *Calyx* superior, 4 or 5-parted, persistent. *Petals* 5 or 10, in 2 whorls, often hooded. *Stamens* numerous, in several whorls, either distinct, or united in bundles. *Ovary* inferior, 1-celled, with several parietal placentas, or 1 axile placenta; *style* 1; *ovules* pendulous, anatropal. *Fruit* capsular, or succulent. *Seeds* having an embryo lying in the axis of fleshy albumen.

Distribution, &c. — They are all natives of North and South America. *Examples:* — Mentzelia, Bartonia, Loasa. There are 18 genera, and about 70 species.

Properties and Uses.— Some of the species are remarkable for their stinging hairs; hence their common name of Chili-Nettles. Several species are cultivated on account of the beauty of their flowers. A Mexican species, *Mentzelia hispida*, is reputed to possess a purgative root.

Natural Order 101. Homaliaceæ.—The Homalium Order.— Trees or shrubs with alternate leaves. *Calyx* superior, funnel-shaped, with from 5—15 divisions. *Petals* equal in number to the divisions of the calyx, with which they are alternate. *Stamens* opposite to the petals and inserted on them, either distinct, or in bundles of 3 or 6. *Ovary* inferior, 1-celled; *placentas* parietal; *ovules* numerous, pendulous; *styles* 3—5. *Fruit* a capsule, or berry. *Seeds* small; *embryo* in the axis of a little fleshy albumen.

Distribution, &c. — They are natives of the tropical parts of India, Africa, and America. *Examples:* — Homalium, Trimeria, Nisa. There are 8 genera, and 30 species.

Properties and Uses. — Some species of *Homalium* are astringent, but nothing is known of the properties of the other genera.

Natural Order 102. Cactaceæ. — The Cactus or Indian Fig Order.— Succulent plants, which are usually spiny, and leafless. *Stems* globular, columnar, flattened, or 3 or more angled, and altogether presenting a peculiar appearance. *Flowers* sessile. *Sepals* and *petals* usually numerous, (*fig.* 934), and scarcely distinguishable from each other; or rarely 4; epigynous. *Stamens* numerous, with long filaments, and versatile anthers (*figs.* 933 and 934). *Ovary* inferior (*fig.* 933), fleshy, 1-celled, with parietal placentas (*fig.* 616); *style* 1; *stigmas*

several. *Fruit* succulent. *Seeds* numerous, parietal, or imbedded in the pulp, without albumen.

Fig. 933.

Fig. 934.

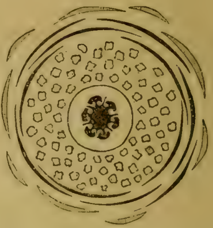


Fig. 933. Vertical section of the flower of the Prickly Pear (*Opuntia vulgaris*).——*Fig.* 934. Diagram of the flower of *Opuntia vulgaris*.

Distribution, &c.—Natives exclusively of the tropical regions of America. *Examples* : — Melocactus, Mammillaria, Echinocactus, Pilocereus, Cereus, Epiphyllum, Rhipsalis, Opuntia, Pereskia. There are 18 genera, and about 800 supposed species.

Properties and Uses.—The fruit of many species is somewhat acid and agreeable, and is useful in febrile complaints. The fleshy stems of the Melon Cactus (*Melocactus*), are eaten by cattle on account of their juice, in the dry districts of South America. Many species of *Cereus*, *Epiphyllum*, *Phyllocactus*, &c., are cultivated on account of their showy flowers. Some species of *Cereus* open their flowers at night; some of the flowers have been measured 1 foot in diameter.

Opuntia vulgaris.— The fruit of this plant is the Prickly Pear, which is much eaten in America and the South of Europe, and has been lately imported into this country. The fruit of *O. Tuna* is of a carmine colour, and has been employed as a water-colour. *O. cochinellifera*, the Nopal Plant, is cultivated in Mexico, &c., for the nourishment of the Cochineal Insect (*Coccus Cacti*).

Natural Order 103. Grossulariaceæ. — The Gooseberry or Currant Order.—Shrubs, with (*fig.* 361), or without spines or prickles. *Leaves* alternate, lobed, radiate-veined. *Flowers* axillary, racemose, perfect or rarely unisexual. *Calyx* superior, 4—5 lobed. *Petals* 5, minute, and inserted on the calyx. *Stamens* 5, inserted on the calyx, and alternate with the petals. *Ovary* inferior, 1-celled with 2 parietal placentas (*fig.*

698 *pl.*). *Fruit* pulpy (*figs.* 698 and 699). *Seeds* numerous; *embryo* minute, in horny albumen.

Distribution, &c.—Natives of the temperate regions of Europe, Asia, and North America. *Examples:*—Ribes, Polyosma. There are but 2 genera, and 95 species.

Properties and Uses.—Some are showy garden plants, as *Ribes fuchsioïdes*, *sanguineum*, *aureum*, *coccineum*, *&c.*, but they are chiefly remarkable for their agreeable acid fruits. Thus, *Ribes Grossularia* is the Gooseberry; *R. rubrum* yields both Red and White Currants, and *R. nigrum* is the Black Currant.

Natural Order 104. ESCALLONIACEÆ.—The Escallonia Order.—Evergreen shrubs, with alternate exstipulate leaves, and axillary showy flowers. *Calyx* superior, 5-toothed, imbricated in æstivation. *Petals* 5, alternate with the divisions of the calyx, and arising from it. *Stamens* 5, alternate with the petals, and inserted on the calyx. *Ovary* inferior, 2—5-celled, crowned by a cone-shaped disk; *placentas* axile; *style* simple; *stigma* 2—5-lobed. *Fruit* capsular or baccate, crowned by the persistent style and calyx. *Seeds* very numerous, minute; *embryo* minute, in a mass of oily albumen.

Distribution, &c.—They are chiefly natives of the mountains of South America. *Examples:*—Escallonia, Forgesia, Itea. There are 7 genera, and 60 species.

Properties and Uses.—Unknown.

Natural Order 105. PHILADELPHACEÆ.—The Syringa Order.—Shrubs. *Leaves* opposite, deciduous, exstipulate. *Calyx* superior, persistent, 4—10-lobed, with a valvate æstivation. *Petals* equal in number to the divisions of the calyx, and alternate with them. *Stamens* numerous, arising from the calyx. *Ovary* inferior; *styles* united or distinct; *stigmas* several. *Capsule* half-inferior, 4—10-celled, *placentas* axile. *Seeds* numerous, with fleshy albumen.

Distribution, &c.—Natives of the South of Europe, North America, Japan, and India. *Examples:*—Philadelphus, Deutzia. There are 4 genera, and 25 species.

Properties and Uses.—Of little importance. The leaves of some species of *Deutzia*, especially those of *D. scabra*, are covered with beautiful scales, hence from their roughness, they are used in Japan for polishing purposes. *Philadelphus coronarius* is commonly cultivated in our shrubberies. It is a native of the south of Europe. It is generally known as the Syringa; or in America, as the Mock Orange, from its flowers somewhat resembling the Orange in appearance and in their powerful odour. This odour is due to the presence of a volatile oil, which may be readily obtained from them by distillation with water. The leaves of the Syringa have a flavour resembling the cucumber.

Natural Order 106. MYRTACEÆ.—The Myrtle Order.—Trees or shrubs. *Leaves* opposite or alternate, entire, exstipulate (*fig.* 935), usually dotted, and having a vein running just within the margin. *Calyx* superior (*fig.* 448), 4 or 5-cleft, valvate, sometimes separating in the form of a cap. *Petals* 4—5, (*fig.* 935), imbricated, rarely absent. *Stamens* usually 8—10, or numerous (*figs.* 448 and 935), or rarely 4—5; *filaments* distinct or polyadelphous; *anthers* ovate. *Ovary* inferior (*fig.* 448), 1—6-celled; *style* and *stigma* simple (*figs.* 448 and 935); *placentas* axile (*fig.* 448), or very rarely parietal. *Fruit* dry or succulent, dehiscent or indehiscent. *Seeds* without albumen, usually numerous.

Fig. 935.

Fig. 935. Flowering branch of the common Myrtle (*Myrtus communis*).

Division of the Order, &c.—The order is divided into two divisions as follows :—

Tribe 1. *Leptospermeæ.* Fruit capsular. *Examples*:—Melaleuca, Eucalyptus, Metrosideros Leptospermum.

Tribe 2. *Myrteæ.* — Fruit baccate. *Examples* : — Punica, Psidium, Myrtus, Caryophyllus, Eugenia, Jambosa.

Distribution, &c. — Natives of the tropics, and of the warmer parts of the temperate zones. *Myrtus communis*, the common Myrtle, is the most northern species of the order. This plant although now naturalised in the south of Europe, was originally a native of Persia. There are about 50 genera, and 1300 species belonging to this order.

Properties and Uses. — The plants of this order are generally remarkable for their aromatic and pungent properties, which are due to the presence of a volatile oil. Many of these oils have been used in medicine, as stimulants, aromatics, carminatives, diaphoretics, or antispasmodics. The parts of some are in common use as spices. Other plants of the order are astringent, and some secrete a saccharine matter. The fruits of some having a sweetish acidulous taste are edible.

Melaleuca minor or *Cajeputi.*— The leaves when allowed to stand so as to undergo a species of fermentation, and then distilled with water, yield a volatile oil of a limpid nature and light green colour, called Cajeput Oil. This was formerly much employed as a remedy in cholera, but without any success. It has been used internally as a diffusible stimulant, antispasmodic, and diaphoretic ; and externally, when mixed with olive oil, as a stimulant embroca-

tion. This oil has the property of dissolving caoutchouc. In Australia, the leaves of *M. scoparia* and *genistifolia* are used as substitutes for Tea.

Eucalyptus resinifera, the Iron Bark, a native of Australia and Van Diemen's Land, yields on incision an astringent substance, called *Botany Bay Kino.* This kino contains a peculiar substance called *Eucalyptin.* It has been employed in diarrhœa. Other species yield a similar substance. The leaves of *E. mannifera* and other species natives of Australia, spontaneously exude a saccharine substance resembling manna, hence this secretion is commonly termed *Australian Manna.* It is said to drop from the trees in pieces sometimes as large as an almond. The secretions of the *Eucalypti* are commonly of a gummy nature, and hence they are called Gum-trees in New Holland. The bark of some of them separates in fibrous layers, which has occasioned them to be also called Stringy-bark trees or Stringy-bark Gum-trees. They are sometimes of a prodigious height,— 200 feet or more, and 10 or 15 feet in diameter, the trunks being destitute of branches to a height of from 100 to 200 feet.

Metrosideros.—The *Lignum Vitæ* or *Aki* of New Zealand, and other species, afford valuable timber. The clubs and weapons of the South Sea Islanders are made from species of this genus.

Leptospermum. — The leaves of *L. scoparium* and *Thea* are used in the Australian colonies as a substitute for tea.

Punica Granatum, the Pomegranate, is repeatedly referred to in the Bible. It is the *rimmon* of the Bible, and the *rooman* of the Arabs. This plant is by some systematists regarded as the type of a distinct order, which is named *Granateæ.* The leaves, the flowers, and the fruit, were all used by the ancients for their astringent properties, and the juice of the fruit also, in the formation of cooling drinks, on account of its acidulous taste. The flowers and fruit are still employed in the East. The flowers are the *Balaustion* of the ancients, whence their common name, *balaustina flowers.* The rind of the fruit, and the bark of the roots, are the parts now commonly used as medicinal agents in this country. These are employed for their astringent properties, and the latter is also commonly regarded as a valuable anthelmintic, but for this purpose the bark of the fresh root should be alone used. The properties of the pomegranate are principally due to tannic acid, and also partly to gallic acid. The bark of the fresh root also contains a peculiar acrid principle called *punicine.*

Psidium.—Various species of this genus yield excellent dessert fruits, which are commonly known under the name of *Guavas.* The more important are, *P. pyriferum*, *P. pomiferum*, *P. Cattleyanum*, *P. albidum*, and *P. pygmeum.*

Glaphyria nitida, is called by the Malays, the Tree of Long Life. It is also known as the Tea Plant, from its leaves being used as tea at Bencoolen.

Myrtus communis, the Common Myrtle. — The dried flower-buds, and the unripe fruit, were used as spices by the ancients, and are still so employed in Tuscany. By distillation with water, the flowers form a very agreeable perfume, known in France as *Eau d'Ange.*

Caryophyllus aromaticus, the Clove-tree. — The dried flower-buds constitute the *cloves* of commerce, which are so well known as a spice; and in medicine, for their aromatic, stimulant, and carminative properties. Their properties are chiefly due to the presence of a volatile oil. The dried unripe fruits are called *mother cloves;* they are used in China and other countries as a spice, and are occasionally imported into this country. They are very inferior to ordinary cloves.

Eugenia Pimenta, the Common Allspice. — The dried unripe fruit is known under the names of *Pimento* or *Jamaica Pepper*, or more commonly as *Allspice* (from its flavour combining that of Cinnamon, Cloves, and Nutmegs). It is used as a spice, and in medicine in similar cases to cloves. Its properties are chiefly due to the presence of a volatile oil. The *Rose-Apples* of the East, which are much esteemed as dessert fruits, are the produce of various species of *Eugenia;* the more important are,—*E. malaccensis*, *E. aquea*, and *E. jambos.* In Brazil, the fruit of *E. cauliflora*, the Jabuticaba, is also much esteemed. The leaves of *E. ugni*, are used in Chili as a substitute for Paraguay Tea. The plant has been recently introduced into this country on account of its fruit, but not with any great success.

Natural Order 107. LECYTHIDACEÆ. — The Brazil-Nut or Monkey-Pot Order. — Large trees, with alternate, dotless

leaves, and small deciduous stipules. *Flowers* large and showy. *Calyx* superior. *Petals* 6, imbricated, distinct, or sometimes united at the base. *Stamens* numerous, epigynous; some of them cohere and form a unilateral petaloid hooded body. *Ovary* inferior, 2 to 6-celled; *placentas* axile. *Fruit* woody, either indehiscent, or opening in a circumscissile manner (*fig.* 669). *Seeds* several, large, and without albumen.

Distribution, &c. — Principally natives of Guiana and Brazil, and also occasionally of other hot regions of South America. *Examples :* — Lecythis, Bertholletia, Couroupita. There are 7 genera, and 38 species.

Properties and Uses. — The plants of this order are chiefly remarkable for their large woody fruits, the pericarps of which are used as drinking-vessels, &c. Their seeds are frequently edible.

Lecythis ollaria.—The fruits of this and other species, have been called Monkey-pots on account of their peculiar shape. The seeds of *L. ollaria* are large and eatable, and are termed Sapucaya-nuts. Some have been lately imported. Other species have also edible seeds. The bark of some species of *Lecythis* may be separated into thin papery layers, which are used by the Indians as wrappers for their cigars.

Bertholletia excelsa, the Brazil-Nut Tree. — The seeds of this plant constitute the edible nuts, known as the Brazil, Juvia, Castanha, or Para Nuts. As many as 50,000 bushels are annually imported into this country from Brazil.

Natural Order 108. CHAMÆLAUCIACEÆ.—The Fringe-Myrtle Order. — *Diagnosis.* — This is a small order of shrubby plants with evergreen dotted leaves, and nearly allied to *Myrtaceæ*, but distinguished from them by their Heath-like aspect, their more or less pappose calyx, and by their truly simple, 1-celled ovary. From *Lecythidaceæ* they are at once known by their habit, their dotted exstipulate leaves, and 1-celled ovary.

Distribution, &c. — Exclusively natives of Australia. *Examples :* — Calytrix, Chamælaucium, Darwinia. There are 15 genera, and 50 species.

Properties and Uses. — Unknown.

Natural Order 109. BARRINGTONIACEÆ.—The Barringtonia Order. — *Diagnosis.* — This is a small order of plants usually placed among the *Myrtaceæ*, but Lindley considers them as quite distinct from that order in these particulars; namely, the presence of a large quantity of albumen in their seeds, and in having alternate, dotless, and often serrated leaves. Thomson has recently proved that the seeds are exalbuminous, so that the characters separating them from Myrtaceæ are very slight indeed. Another character of distinction is, in the æstivation of the calyx in the two orders respectively; thus that of Myrtaceæ is valvate, that of Barringtoniaceæ imbricated.

Distribution, &c. — Natives of tropical regions in all parts of the world. *Examples :* — Barringtonia, Careya, Gustavia.

Properties and Uses. — The bark of *Stravadium racemosum* is

reputed to be febrifugal, and the root bitter, aperient, and acrid. The fruit of *Careya arborea* is eaten, while that of *Gustava braziliana* is emetic, and produces an intoxicating effect upon fish. Generally the plants of the order should be regarded as somewhat dangerous.

Natural Order 110. BELVISIACEÆ.—The Belvisia Order.—Shrubs. *Leaves* alternate, exstipulate, with a leathery texture. *Calyx* superior, coriaceous, 5-parted, with a valvate æstivation. *Corolla* consisting of three distinct whorls of united petals. *Stamens* 20, unequally monadelphous. *Disk* fleshy, and forming a cup-shaped expansion over the ovary. *Ovary* 5-celled, with two ovules in each cell; *placentas* axile; *style* 5-angled or 5-winged; *stigma* pentagonal. *Fruit* a soft rounded berry, crowned by the calyx. *Seeds* large, kidney-shaped, exalbuminous.

Distribution, &c.—Natives of tropical Africa. *Examples:*—Asteranthos, Napoleona. These are the only genera, and they include 4 species.

Properties and Uses.—Nothing is known of their uses, except that the pulp of their fruits is edible, and the pericarp contains much tannin. They might be used as astringents.

Natural Order 111. MELASTOMACEÆ.—The Melastoma Order.—Trees, shrubs, or herbs. *Leaves* opposite, and almost always ribbed and dotless. *Calyx* 4, 5, or 6-lobed, more or less adherent to the ovary, imbricated. *Petals* equal in number to the divisions of the calyx, twisted in æstivation. *Stamens* equal in number, or twice as many as the petals; *filaments* curved downwards in æstivation; *anthers* long, 2-celled, curiously beaked, usually dehiscing by two pores at the apex, or sometimes longitudinally, in æstivation lying in spaces between the ovary and sides of the calyx. *Ovary* more or less adherent, many-celled. *Fruit* either dry, distinct from the calyx, and dehiscent; or succulent, united to the calyx, and indehiscent. *Seeds* very numerous, minute, exalbuminous.

Distribution, &c.—They are principally natives of tropical regions in all parts of the world, but a few are also extra tropical, being found in North America, China, Australia, and in the northern provinces of India. *Examples:*—Siphanthera, Melastoma, Lasiandra, Osbeckia, Rhexia, Medinilla, Sonerila, Memecylon, Mouriria. There are 166 genera, and about 2000 species.

Properties and Uses.—The prevailing character of this order is a slight degree of astringency. Many produce edible fruits, and some are used for dyeing black and other colours. The name *Melastoma* is derived from the fruits of the species dyeing the mouth black. The leaves of *Memecylon tinctorium* are used in some parts of India for dyeing yellow, &c. Generally speaking, the plants possess but little interest in a medical or economical point of view, but none are unwholesome. A

number of species are cultivated in this country on account of the beauty of their flowers.

Natural Order 112. ONAGRACEÆ. — The Evening Primrose Order. — General Character. — Herbs or shrubs. *Leaves* alternate or opposite, simple, exstipulate, without dots. *Calyx* (*fig.* 936) superior, tubular, with the limb usually 4-lobed, or sometimes 2-lobed (*fig.* 765); in æstivation valvate. *Petals* usually large and showy, generally regular and equal in number to the divisions of the calyx (*figs.* 765 and 936), twisted in æstivation, and inserted into the throat of the calyx, rarely absent. *Stamens* (*figs.* 765 and 936) definite, 2, 4, or 8, or rarely by abortion 1, inserted with the petals into the throat of the calyx; *filaments* distinct; *pollen* trigonal (*figs.* 559 and 561). *Ovary* inferior (*fig.* 936), 2—4-celled; *placentas* axile; *style* 1, filiform; *stigma* lobed, or capitate. *Fruit* capsular, or succulent and indehiscent, 1, 2, or 4-celled. *Seeds* numerous (*fig.* 936), without albumen; *embryo* straight.

Fig. 936.

Fig. 936. Vertical section of the flower of a Willow-herb (*Epilobium*).

Diagnosis.—Herbs or shrubs, with simple, exstipulate, dotless leaves. Calyx superior, 2—4-lobed, valvate in æstivation. Petals usually equal in number to the lobes of the calyx, with a twisted æstivation, or rarely absent. Stamens few, (usually 2, 4, or 8), inserted into the throat of the calyx with the petals. Ovary inferior, 2—4-celled; style simple; stigma lobed, or capitate. Fruit dehiscent or indehiscent. Seeds numerous, without albumen.

Distribution, &c. — Chiefly natives of the temperate parts of North America and Europe; many are also found in India, but they are rare in Africa except at the Cape. *Examples:* — Jussiæa, Isnardia, Œnothera, Godetia, Clarkia, Epilobium, Montinia, Fuchsia, Circæa, Gaura. There are 30 genera, and 450 species.

Properties and Uses.—Unimportant. Generally the plants are harmless, and possess mucilaginous properties. The roots of *Œnothera biennis* and other species are edible. The fruits of many *Fuchsias* are somewhat acid, and good to eat. Some species of *Jussiæa* are astringent. Several species of *Œnothera* open their yellow flowers in the evening, and hence they have been called Evening Primroses.

Natural Order 113. HALORAGACEÆ. — The Mare's Tail or Water-Chestnut Order.—*Diagnosis.*—Herbs or shrubs, generally aquatic. Flowers small (*fig.* 389), frequently incomplete and unisexual. They are nearly allied to Onagraceæ, and, in fact are merely a degeneration or imperfect form of that order. They

are known from it by their minute calyx, the limb of which is frequently obsolete; and by having solitary pendulous seeds, which have fleshy albumen, or are exalbuminous.

Distribution, &c. — They are found in all parts of the world. *Examples:* — Hippuris, Myriophyllum, Loudonia, Trapa. There are 10 genera, and 70 species.

Properties and Uses. — Of little importance except for their edible seeds.

Trapa.—This is a genus of floating aquatic plants, remarkable for their horned fruit, and large amygdaloid seeds with unequal cotyledons. The seeds are edible. *Trapa natans* is the *Marron d'Eau* or Water-Chestnut; *T. bicornis* is called *ling* by the Chinese, and its seeds are highly esteemed by them. *T. bispinosa* is the Singhara Nut, and is largely consumed in Cashmere and some other parts of India.

Natural Order 114. COMBRETACEÆ.—The Myrobalan Order. — Trees or shrubs. *Leaves* exstipulate, entire, without dots. *Flowers* perfect or unisexual. *Calyx* superior, with a 4—5-lobed deciduous limb. *Petals* equal in number to, and alternate with, the lobes of the calyx; often absent. *Stamens* inserted with the petals on the calyx, generally twice as numerous as the lobes of the calyx, or thrice as many, or equal to them in number; *anthers* 2-celled, with longitudinal or valvular dehiscence. *Ovary* inferior, 1-celled, with 2—4 pendulous ovules; *style* and *stigma* simple. *Fruit* indehiscent, 1-seeded. *Seeds* exalbuminous; *cotyledons* leafy, convolute or plaited.

Distribution, &c.— Exclusively natives of the tropical parts of America, Africa, and Asia. *Examples:* — Terminalia, Conocarpus, Combretum, Gyrocarpus. There are 22 genera, and 200 species.

Properties and Uses.— The order is chiefly remarkable for the presence of an astringent principle, hence the barks of some species, and the fruits and flowers of others, are employed in tanning and dyeing. Some yield excellent timber. *Combretum butyrosum*, a native of South-eastern Africa, produces a kind of vegetable butter, which is called *Chiquito* by the Caffres, by whom it is used to dress their victuals.

Terminalia Chebula. — The fruits are largely imported into this country under the name of *Myrobalans* or *Myrabolams.* Those of *T. belerica*, called *Bastard myrobalans*, or *Bedda nuts*, of *T. citrina*, and probably those of other species, have similar properties. They form good durable yellow and black dyes, and are also used in tanning. The flowers of *T. Chebula* are also used as a dye in Travancore. They have been also employed in medicine, as astringents and tonics. The seeds of *T. belerica* are edible, as are also those of *T. Catappa* and some other species. The seeds of *T. citrina* are purgative. *T. Benzoin* has a milky juice, which upon drying, forms a fragrant and resinous substance resembling Benzoin in its properties.

Natural Order 115. RHIZOPHORACEÆ.—The Mangrove Order. —Trees (*fig.* 235) or shrubs. *Leaves* simple, opposite, dotless or rarely dotted, with deciduous interpetiolar stipules. *Calyx* superior, 4—12-lobed, with a valvate æstivation, the lobes sometimes united so as to form a calyptra. *Petals* arising from

the calyx, alternate with its lobes, and equal to them in number. *Stamens* on the calyx, twice or thrice as many as its lobes, or still more numerous. *Ovary* inferior, 2, 3, or 4-celled, each cell with 2 or more pendulous ovules. *Fruit* indehiscent, 1-celled, 1-seeded, crowned by the calyx. *Seed* pendulous, exalbuminous, usually germinating while the fruit is still attached to the tree.

Distribution, &c. — Natives of muddy sea-shores in tropical regions. *Examples*:—Rhizophora, Kandelia, Bruguiera. There are 5 genera, and 20 species.

Properties and Uses. — Generally remarkable for their astringent properties, whence they are used for dyeing and tanning, and also in medicine as febrifuges and tonics.

Rhizophora Mangle. The Mangrove-Tree (*fig.* 235).—The bark is sometimes imported into this country as a tanning material, but it is not much used. The fruit is sweet and edible, and its juice when fermented forms a kind of wine.

Natural Order 116. ALANGIACEÆ.—The Alangium Order. —Trees or shrubs. *Leaves* alternate, entire, exstipulate, without dots. *Calyx* superior, 5—10-toothed. *Petals* 5—10, linear, reflexed. *Stamens* equal in number, or twice, or four times as numerous as the petals; *anthers* adnate. *Ovary* inferior, 1—2-celled; *style* simple; *ovules* solitary, pendulous. *Fruit* drupaceous, more or less united to the calyx, 1-celled. *Seed* solitary, pendulous, with fleshy albumen and large flat leafy cotyledons.

Distribution, &c.—Natives of various parts of the East Indies and the United States. *Examples*:—Alangium, Marlea, Nyssa. There are 4 genera and 8 species.

Properties and Uses:— Of little importance. Some species of *Alangium* are said to be purgative and aromatic; their succulent fruits are also edible. The fruit of *Nyssa capitata* or *candicans* is used occasionally as a substitute for Lime fruit, whence it is called the *Ogechee Lime*.

Natural Order 117. CORNACEÆ. — The Cornel or Dogwood Order. — General Character.—Shrubs, trees, or rarely herbs. *Leaves* simple, opposite, or very rarely alternate, exstipulate. *Flowers* perfect, or rarely unisexual, arranged in heads, or in a corymbose, or umbellate manner, with or without an involucre. *Calyx* superior, 4-lobed. *Petals* 4, broad at the base, inserted at the top of the calyx-tube; *æstivation* valvate. *Stamens* 4, inserted with the petals, and alternate to them. *Ovary* inferior, surmounted by a disk, 2-celled; *ovules* pendulous, solitary, anatropous; *style* and *stigma* simple. *Fruit* drupaceous, crowned with the remains of the calyx. *Seeds* pendulous, solitary; *embryo* in the axis of fleshy albumen, to which it is nearly equal in length; *cotyledons* large and leafy.

Diagnosis.—Trees, shrubs, or rarely herbs, with simple, exstipulate, and (with but one exception) opposite leaves. Flowers perfect, or sometimes unisexual. Calyx superior, 4-lobed. Co-

rolla with 4 petals, and a valvate æstivation. Stamens 4, alternate with the petals. Ovary inferior, usually 2-celled, with a single pendulous anatropous ovule in each cell; style and stigma simple. Fruit drupaceous. Embryo in the axis of fleshy albumen.

Distribution, &c.—Natives of the temperate parts of Europe, Asia, and America. *Examples:*—Benthamia, Cornus, Aucuba. There are 9 genera, and 40 species.

Properties and Uses.—The plants of this order are chiefly remarkable for tonic, febrifugal, and astringent properties.

Cornus florida.—The bark of this plant is much esteemed in the United States of America as a substitute for Peruvian bark in the treatment of intermittent and remittent fevers. It is commonly known under the name of *dog wood bark*. The bark of *C. circinata* and *C. sericea* are also used for similar purposes in North America. The fruit of *C. mascula*, the Cornelian Cherry, is astringent, a property also possessed by the leaves and flowers. The fruit, called *krania*. is much esteemed by the Turks, on account of its agreeable acid flavour. They use the juice in their sherbets, and for other purposes. The fruit of *C. succica* is reputed to possess tonic properties. The seeds of *C. sanguinea*, the common dog-wood of our hedges, yield a fixed oil, which has been used for burning in lamps.

Aucuba japonica, as its name implies, is a native of Japan, but it is now commonly cultivated in our gardens and shrubberies. It is remarkable for its variegated leaves. The female plant is alone known in this country, hence it never produces seeds, and can therefore only be propagated by layering, or by slips, or cuttings.

Natural Order 118. HAMAMELIDACEÆ.—The Witch-Hazel Order.—Small trees or shrubs, with alternate leaves, and deciduous stipules. *Flowers* perfect or unisexual. *Calyx* superior, 4 or 5-lobed. *Petals* 4 or 5, with an imbricated æstivation, or altogether wanting. *Stamens* 8, half of which are sterile and placed opposite to the petals, and half fertile and alternate with them; *anthers* 2-celled, introrse. *Ovary* inferior, 2-celled; *styles* 2. *Fruit* capsular, 2-valved, with a loculicidal dehiscence. *Seeds* pendulous, albuminous.

Distribution, &c.—Natives of North America, China, Japan, the central parts of Asia, Madagascar, and South Africa.

Properties and Uses.—Unimportant.

Hamamelis virginica yields oily edible seeds, and its leaves and bark possess astringent properties.

Rhodoleia Championi, a native of China, has showy flowers. It has recently flowered for the first time in England.

Natural Order 119. BRUNIACEÆ.—The Brunia Order.—Heath-like shrubs, with small, imbricated, rigid, entire, exstipulate leaves. *Calyx* usually superior, or sometimes nearly inferior, imbricated. *Petals* and *stamens* 5, inserted on the calyx, the petals alternate with the divisions of the calyx, and imbricated; *anthers* 2-celled, extrorse, bursting longitudinally. *Ovary* superior, or half-inferior, 1—3-celled, with 1 or 2 suspended anatropal ovules in each cell; *style* simple or bifid. *Fruit* crowned by the calyx, 1 or 2-celled, in the first case indehiscent, in the latter dehiscent. Seeds with a minute embryo in fleshy albumen.

Distribution, &c.—Natives of the Cape of Good Hope except one Madagascar species. *Examples:*—Brunia, Raspailia, Grubbia, Ophiria. There are 15 genera, and 65 species.

Properties and Uses.—Unknown.

Natural Order 120. Umbelliferæ or Apiaceæ.—The Umbelliferous Order.—General Character.—Herbs or small shrubs, with hollow or solid stems. *Leaves* alternate, generally sheathing at the base (*fig.* 258), usually compound (*fig.* 340), or sometimes simple, exstipulate. *Flowers* generally in umbels, (*figs.* 375, 407 and 937), white, pink, yellow, or blue, with (*fig.*

Fig. 937.

Fig. 938.

Fig. 939.

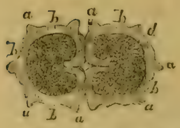


Fig. 940.

Fig. 937, c. General umbel of Fool's Parsley (*Æthusa Cynapium*), in fruit. *b.* One of the umbellules, showing the 3-leaved, partial, pendulous, involucel.——*Fig.* 938. A side view of the ripe fruit of the Hemlock (*Conium maculatum*).——*Fig.* 939. Transverse section of the fruit —— of the same. *Fig.* 940. Vertical section of one of the halves of the fruit (mericarp). The letters refer to the same parts in these last figures. *a, a.* Ridges. *b, b.* Channels. *d.* Albumen. *f.* Embryo. *g.* Remains of the styles. *h.* axis. i. prolonged axis, or Carpophore.

375) or without (*fig.* 407) an involucre. *Calyx* (*fig.* 563) superior, the limb entire, or 5-toothed, or obsolete. *Petals* 5 (*fig.* 563) usually inflexed at the point, often unequal in size, inserted on the calyx outside the disk which crowns the ovary; *æstivation* imbricate, or rarely valvate. *Stamens* 5, inserted with the petals, and alternate with them (*fig.* 563), incurved in æstivation. *Ovary* inferior (*fig.* 563), crowned by a double fleshy disk (*stylopod*) (*fig.* 563 *d*), 2-celled, with a solitary pendulous ovule in each cell; *styles* 2 (*fig.* 938 *g*); *stigmas* simple. *Fruit* called a *cremocarp* or *diachænium* (*figs.* 136, 697, 938 and 939), consisting of 2 carpels (*mericarps*), adhering by their face (*commissure*) to a common axis (*carpophore*), from which they ultimately

separate and become pendulous; each carpel an indehiscent 1-seeded body, traversed on its dorsal surface by *ridges*, of which 5 are primary, and sometimes 4 others, alternating with them, secondary; the spaces between the ridges are called channels (*valleculæ*), in which are sometimes linear oily receptacles called *vittæ* (*fig.* 136). *Seed* pendulous (*fig.* 940); *embryo* minute, at the base of abundant horny albumen (*fig.* 940); *radicle* pointing towards the hilum.

Diagnosis.—Herbs or shrubs. Leaves alternate, usually compound and sheathing at the base, or sometimes simple, exstipulate. Flowers almost always arranged in a more or less umbellate manner. *Calyx* superior. Petals and stamens 5, inserted on the outside of a double fleshy disk which crowns the ovary. Ovary inferior, 2-celled, with a solitary pendulous ovule in each cell; styles 2. Fruit consisting of two indehiscent carpels, which separate when ripe from a common axis or carpophore. Seeds pendulous, one in each carpel, with a minute embryo at the base of abundant horny albumen.

Division of the Order, &c.—The order has been divided into three sections or sub-orders, from the appearance of the albumen, but they are by no means well defined. They are as follows:—

Sub-order 1. *Orthospermeæ.*—Albumen flat on its face. *Examples:*—Hydrocotyle, Bolax, Sanicula, Horsfieldia, Cicuta, Petroselinum, Œnanthe, Fœniculum, Pachypleurum, Levisticum, Opoponax, Heracleum, Galbanum, Cuminum, Thapsia, Daucus.

Sub-order 2. *Campylospermeæ.*—Albumen rolled inwards at the edges, and presenting a vertical furrow on its face. *Examples:*—Margotia, Torilis, Anthriscus, Chærophyllum, Conium, Prangos, Opoidia.

Sub-order 3. *Cœlospermeæ.*—Albumen with the base and apex curved inwards on its face. *Examples:*—Ormosciadium, Atrema, Coriandrum.

Distribution, &c.—Chiefly natives of the northern parts of Europe, Asia, and America. Many occur, however, in the southern hemisphere. They are rare in tropical regions except upon the mountains, where they are by no means uncommon. There are about 288 genera, and 1550 species.

Properties and Uses.—Extremely variable; thus, some are edible; others are aromatic and carminative, and, in some cases, stimulant and tonic, from the presence of a volatile oil; others contain a narcotico-acrid juice, which renders them more or less poisonous; while others again are antispasmodic and stimulant from the presence of a fœtid gum-resin, which is essentially composed of gum, resin and volatile oil. This oil in the case of Assafœtida, and probably in some of the others, contains sulphur.

We shall allude to the more important umbelliferous plants under the above arrangement of their properties.

1. Esculent Umbelliferæ.

Anthriscus Cerefolium, Chervil, was formerly used for its edible roots, and as a pot-herb.

Apium graveolens, Celery.—By cultivation with the absence of light, the stem and petioles become succulent and develop but little aromatic oil, and are then edible.

Anesorhiza capensis is eaten at the Cape of Good Hope.

Arracacha esculenta, Arracacha, a native of New Granada, has large esculent roots.

Bunium flexuosum and *Bulbocastanum* have edible tubers, which are known under the name of Earth-nuts or Pig-nuts. *B. ferulaceum*, a native of Greece, has also edible tubers, which are termed *Topana*.

Crithmum maritimum, Samphire, is commonly used as an ingredient in pickles.

Daucus Carota, var. *sativa*, the cultivated or Garden Carrot, is well-known for its esculent roots. These are also used in medicine in the form of a poultice for their moderately stimulant properties.

Fœniculum vulgare is the Common Fennel, and *F. dulce* the Sweet Fennel. Both are well-known as pot-herbs and garnishing substances. The latter is frequently considered as a cultivated variety of the former. *F. capensis* is a Cape esculent.

Ferula.—The roots of several species of this genus, and of other allied plants, are eaten in Oregon and some other parts of North America.

Haloscias scoticum is the Scottish Lovage.

Helosciadum californicum.—The roots are said by M. Geyer, to be very delicious; they are eaten by the Saptoria Indians in Oregon.

Œnanthe pimpinelloides is said by Lindley to have wholesome roots, but the genus generally must be regarded with suspicion.

Pastinaca sativa, the Parsnip.—The roots of the cultivated plant are the parts eaten.

Petroselinum sativum is the Common Parsley of our gardens.

Prangos pabularia.—The herb is used as sheep food in Tartary and the adjoining countries.

Sium Sisarum, is commonly known under the name of Skirret.

Smyrnium Olusatrum Alexanders.—This plant was formerly cultivated like Celery.

2. Aromatic, Carminative, Stimulant, and Tonic Umbelliferæ.

Archangelica officinalis, Angelica.—The root and fruits are pungent aromatic stimulants, and mild tonics. They are principally used in the preparation of gin, and the liqueur known under the name of *bitters*. The young shoots are also made with sugar into a sweetmeat or candy, which forms a very agreeable stomachic.

Anethum graveolens, the Dill; *Carum Carui*, the Caraway; *Coriandrum sativum*, the Coriander; *Cuminum Cyminum*, the Cummin; *Daucus Carota*, the Carrot; *Fœniculum vulgare*, the Common Fennel; *Fœniculum dulce*, the Sweet Fennel; *Fœniculum Pannorium*, an Indian species; and *Pimpinella Anisum*, the Anise. The fruits of the above plants, commonly termed seeds, all possess aromatic, carminative, and more or less stimulant properties, which are due to the presence of volatile oils contained chiefly in the *vittæ*, or pericarp. Some are also employed as condiments, and for flavouring liqueurs. They are too well known to need any detailed description. The fruits of *Levisticum officinale*, Lovage, have somewhat similar properties.

Eryngium campestre and *maritimum*, Eryngo, have sweet aromatic roots, possessing tonic properties.

Meum athamanticum, Bald-money, and *M. Mutellina*, possess roots of a similar nature to the preceding.

Sumbul is the root of a supposed Umbelliferous plant, which is imported into this country from Bombay and Russia. It has a strong musky smell, hence its common name of *Musk-root*. It possesses stimulant and antispasmodic pro-

perties. From recent investigations, it would appear that sumbul is the root of *Nardostachys Jatamansi*, a plant belonging to the Valerianaceæ (see p. 573).

Hydrocotyle asiatica. — This plant is now employed in India both internally and externally, in leprosy, secondary syphilis, &c. It is said with much benefit.

3. Poisonous Umbelliferæ.

The poisonous properties are due to the presence of a narcotico-acrid juice, and seem to vary according to the nature of the soil and climate, for Dr. Christison has noticed, that certain species which are generally regarded as poisonous, are quite harmless when obtained from some localities near Edinburgh. This is a very important point, and one which requires further investigation. Should it prove to be true in all cases, it would account in a great degree for the varying strength of the officinal preparations of Hemlock, and which is commonly regarded to arise from their careless preparation.

Æthusa Cynapium, Fool's Parsley, is a very common indigenous plant possessing poisonous properties. It has been mistaken and eaten for Parsley.

Cicuta virosa, Water Hemlock or Cowbane, is another indigenous plant of a highly poisonous nature. *C. maculata*, a native of America, has very poisonous roots, which from having been mistaken for other harmless *Umbelliferæ*, have not unfrequently led to fatal results.

Conium maculatum, Hemlock.—This plant is indigenous. In proper doses it is extensively employed in medicine to relieve pain, relax spasm, and compose nervous irritation in general. It owes its properties chiefly, to the presence of a colourless oily liquid with a penetrating mouse-like odour, to which the name of *Conia* has been given. In improper doses, Hemlock is a powerful poison, and many fatal accidents have arisen from its having been mistaken for other harmless Umbelliferous plants.

Œnanthe crocata, Hemlock,—Drop-wort or Dead-tongue, and *Œnanthe Phellandrium*, Fine-leaved Water-dropwort, are intensely poisonous in most localities. The roots of *Œnanthe pimpinelloides*, as already noticed (see p. 561), are said to be wholesome. All the above species are indigenous.

4. Umbelliferæ yielding fœtid Gum Resins.

There are many plants belonging to this order which yield fœtid gum-resins. The most important of these gum-resins are, *Opoponax*, *Sagapenum*, *Assafœtida*, *Ammoniacum*, and *Galbanum*. The latter four are officinal in the British Pharmacopœias. They all possess antispasmodic and more or less stimulant properties; this is especially the case with Assafœtida, which is also extensively used as a condiment in Persia and some of the adjacent countries, in the same way as garlic and other allied plants are employed in Europe. Ammoniacum also possesses expectorant properties to some extent, and both it and Galbanum are used externally in the form of plasters, to promote the absorption of tumours and chronic swellings of the joints. The plants yielding these gum-resins are not in all cases known, but they are exclusively natives of Persia, and the adjacent regions, except the one yielding Opoponax, which is only found in the south of Europe, and in Syria. These gum-resins are imported into this country from Turkey, the Levant, or India. They are commonly seen in two forms, — that is, in roundish or irregular tears, or in masses formed by their union.

Opoponax appears to be obtained from incisions into the root of *Opoponax Chironium*, formerly called *Pastinaca Opoponax*.

Sagapenum. — Nothing positive is known with respect to the plant yielding this substance. It has been supposed to be obtained from the root of *Ferula persica*, or some other species of *Ferula*.

Assafœtida. — This is obtained by incisions into the root of *Narthex* or *Ferula Assafœtida*, and probably also to some extent from *Ferula persica* or some other species, or from some other plants. Royle suggests that *Prangos pabularia* may be one of the sources. There is no doubt, however, as to *Narthex assafœtida* producing the greater part of the Assafœtida of commerce, and it may be found to be the only source.

Ammoniacum is yielded by *Dorema ammoniacum*. It exudes from the stem probably to some extent spontaneously, but principally in consequence of punctures produced by innumerable beetles, when the plant has attained perfection.

Galbanum. — The source of this gum-resin is still uncertain. Lindley

supposes it to be an exudation from the stem of *Opoïdia galbanifera*, but of this there is no proof. By Don it has been referred to *Galbanum officinale*.

Natural Order 121. Araliaceæ.—The Ivy Order.—General Character.—Trees, shrubs, or herbs. *Leaves* alternate (*fig.* 203), without stipules. *Flowers* generally in umbels, or capitate, usually perfect (*fig.* 941), or rarely unisexual. *Calyx* more or less superior (*fig.* 941), entire or toothed. *Petals* (*fig.* 941), 2, 4, 5, 10, deciduous, almost always valvate in æstivation, or rarely imbricate, generally distinct, or rarely monopetalous, occasionally wanting. *Stamens* corresponding in number to the petals, and alternate with them (*fig.* 941), or twice as many, inserted on the outside of a disk which crowns the ovary; *anthers* turned inwards (*fig.* 941), with longitudinal dehiscence. *Ovary* (*fig.* 941), more or less inferior, usually with more than 2 cells, or very rarely 1-celled, crowned by a disk, each cell with a solitary pendulous anatropal ovule; *styles* as many as the cells, sometimes united; *stigmas* simple. *Fruit* usually 3 or more celled, succulent or dry, each cell with 1 pendulous seed with fleshy albumen.

Fig. 941.

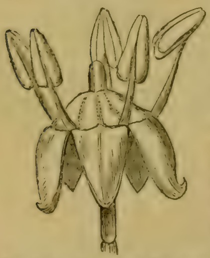


Fig. 941. Flower of the common Ivy (*Hedera Helix*).

Diagnosis.—Closely allied to *Umbelliferæ*, from which it may be usually distinguished by the valvate æstivation of the corolla; by having commonly more than 2 cells and 2 styles to the ovary; by the fruit being 3 or more celled, the carpels of which do not separate when ripe from a forked carpophore; and from the seed possessing fleshy albumen. There is also a greater tendency among *Araliaceæ* to form a woody stem than in *Umbelliferæ*.

Distribution, &c.—These plants are universally distributed, being found in tropical, sub-tropical, temperate, and the coldest regions. *Examples*:—Panax, Aralia, Hedera, Adoxa, Gunnera. There are 21 genera, and 160 species.

Properties and Uses.—It must be regarded as a somewhat remarkable fact, that nearly allied as the Araliaceæ are to the Umbelliferæ, they never possess to any degree, the poisonous properties which are frequently found in plants of that order. The Araliaceæ are generally stimulant, aromatic, diaphoretic, and somewhat tonic.

Panax Schinseng or *Ginseng.*—The root of this plant is the *Asiatic Ginseng* which is so highly prized by the Chinese as a stimulant and aphrodisiac, that they will sometimes give for it its weight in gold. It is thought very little of in Europe. *P. quinquefolium*, is a native of North America. Its root is known under the name of *American Ginseng*. It has similar properties to the preceding.

Aralia nudicaulis is a native of North America, where its roots are used popularly as an alterative and stimulant diaphoretic in rheumatic affections. It is commonly known under the name of *False* or *American Sarsaparilla*. It is sometimes forwarded to this country. The bark of *A. spinosa*, called *Angelica*, or *Toothache-tree* in North America, is used as a stimulant diaphoretic. The rice paper of the Chinese has been ascertained by Sir William Hooker to be prepared from the pith of a plant, named by him *Aralia papyrifera*. (See *Æschynomene paludosa*, p. 527. *A. racemosa*, *spinosa*, and *hispida* yield aromatic gum-resins.

Dimorphanthus or *Aralia edulis*, is used in China as a diaphoretic. Its young shoots and roots are also eaten as vegetables in China and Japan.

Hedera Helix, the Ivy, is reputed to be diaphoretic, and its berries are emetic and purgative.

Gunnera scabra is remarkable for its enormous leaves, which are sometimes as much as eight feet in diameter. Its fleshy leaf-stalks, which resemble those of the Rhubarbs in appearance, are eaten. Its roots are astringent.

Artificial Analysis of the Natural Orders in the Sub-class CALYCIFLORÆ. — Modified from Lindley.

(The Numbers refer to the Orders.)

1. FLOWERS POLYANDROUS.—Stamens more than 20.

A. Ovary wholly superior.
- *a. Leaves without stipules.*
  - 1. *Carpels more or less distinct, (at least as to the styles); or solitary.*
    - Stamens distinctly perigynous. Ovules suspended or ascending . . . . . *Rosaceæ.* 82.
    - Stamens more or less hypogynous. Ovules attached to a long funiculus arising from the base of the cell . . . . . *Anacardiaceæ.* 76.
  - 2. *Carpels combined into a solid pistil.*
    - Sepals 2, coherent at the base only. Ovary with a free central placenta . . . . *Portulacaceæ.* 92.
    - Sepals more than 2, coherent into a tube. Ovary with axile placentas . . . . *Lythraceæ.* 84.
- *b. Leaves with stipules.*
  - 1. *Carpels more or less distinct, (at least as to the styles); or solitary.*
    - Calyx with the odd lobe inferior. Stamens more or less hypogynous . . . . . *Leguminoseæ.* 80.
    - Calyx with the odd lobe superior. Stamens perigynous . . . . *Rosaceæ.* 82.
  - 2. *Carpels combined into a solid pistil.*
    - Ovary 1-celled with a free central placenta . *Portulacaceæ.* 92.

B. Ovary inferior, or partially so.
- *a. Leaves without stipules.*
  - 1. *Placentas parietal.*
    - Petals definite in number, distinct from the calyx . . . . *Loasaceæ.* 100.
    - Petals indefinite in number, gradually passing into the sepals . . . . *Cactaceæ.* 102.
  - 2. *Placentas in the axis.*
    - Leaves with transparent dots.
      - Ovary 1-celled. Cotyledons not distinct *Chamælauciaceæ.* 108.
      - Ovary with more than 1 cell. Cotyledons distinct . . . . *Myrtaceæ.* 106.
    - Leaves without dots.
      - Petals very numerous . . . . . *Mesembryaceæ.* 93.
      - Petals definite in number.
        - Petals narrow and strap-shaped . . *Alangiaceæ.* 116.
        - Petals roundish and concave.
          - Styles united . . . . *Barringtoniaceæ.* 109.
          - Styles distinct . . . . *Philadelphaceæ.* 105.

b. Leaves with stipules.
1. *Carpels more or less distinct, or solitary* . *Rosaceæ.* 82.
2. *Carpels combined into a solid pistil.*
Leaves opposite . . . . . . *Rhizophoraceæ.* 115.
Leaves alternate.
Placentas axile . . . . . . *Lecythidaceæ.* 107.
Placentas parietal . . . . . *Homaliaceæ.* 101.

2. FLOWERS OLIGANDROUS.—Stamens less than 20.

A. Ovary wholly superior.
a. Leaves without stipules.
1. *Carpels more or less distinct, or solitary.*
Carpels with hypogynous scales.
Each carpel having one scale . . . *Crassulaceæ.* 89.
Each carpel having two scales . . . *Francoaceæ.* 90.
Carpels without hypogynous scales.
Carpels several all perfect . . . . *Calycanthaceæ.* 83.
Carpel solitary, or all but one imperfect.
Leaves without dots.
Ovule single, suspended by a cord rising from the base of the carpel . . *Anacardiaceæ.* 76.
Ovules collateral, ascending, sessile . *Connaraceæ.* 78.
Leaves dotted . . . . *Amyridaceæ.* 79.
2. *Carpels combined, (at least by their ovaries) into a solid pistil.*
Placentas parietal.
Flowers with a ring or crown of sterile stamens.
Flowers unisexual.
Female flower coronetted . . *Pangiaceæ.* 98.
Female flower not coronetted . *Papayaceæ.* 97.
Flowers hermaphrodite . . . . *Malasherbiaceæ.* 95.
Flowers without sterile stamens . . *Turneraceæ.* 96.
Placentas axile.
Styles distinct to the base.
Carpels each with one hypogynous scale *Crassulaceæ.* 89.
Carpels without hypogynous scales . *Saxifragaceæ.* 85.
Styles more or less combined.
Calyx imbricate.
Sepals 2. . . . . *Portulacaceæ.* 92.
Sepals more than 2.
Ovules ascending . . . . . *Celastraceæ.* 71.
Ovules suspended . . . . . *Bruniaceæ.* 119.
Calyx valvate or open.
Stamens opposite to the petals, isomerous . . . . *Rhamnaceæ.* 75.
Stamens alternate with the petals if isomerous.
Leaves simple. Calyx tubular . *Lythraceæ.* 84.
Leaves compound. Calyx not tubular . . . . *Amyridaceæ.* 79.
b. Leaves with stipules.
1. *Carpels distinct, or solitary.*
Fruit leguminous; odd sepal inferior . . *Leguminosæ.* 80.
Fruit not leguminous; odd sepal superior . *Rosaceæ.* 82.
2. *Carpels combined, (at least by their ovaries) into a solid pistil.*
Placentas parietal.
Flowers with a ring of appendages . . *Passifloraceæ.* 94.
Flowers without a ring of appendages . *Moringaceæ.* 81.
Placentas in the axis.
Styles distinct to the base.
Petals minute . . . . . . *Paronychiaceæ.* 91.
Petals conspicuous.
Leaves opposite . . . . . *Cunoniaceæ.* 88.
Leaves alternate . . . . . *Saxifragaceæ.* 85.

Styles more or less combined.
Calyx imbricate.
Flowers spurred . . . . . *Vochysiaceæ.* 74.
Flowers not spurred.
Leaves simple. Petals united by their claws into a tube . . . *Stackhousiaceæ.* 72.
Leaves compound. Petals distinct *Staphyleaceæ.* 73.
Calyx valvate or open.
Stamens opposite to the petals, isomerous . . . . *Rhamnaceæ.* 75.
Stamens twice as many as the petals . *Amyridaceæ.* 79.
B. Ovary inferior, or partially so.
a. Leaves without stipules, or with cirrhose stipules.
Placentas parietal.
Flowers completely unisexual. Monopetalous . . . . *Cucurbitaceæ.* 99.
Flowers hermaphrodite, or polygamous.
Petals distinct . . . . *Grossulariaceæ.* 103.
Placentas in the axis.
Flowers in umbels.
Styles two . . . . *Umbelliferæ.* 120.
Styles three or more . . . . . *Araliaceæ.* 121.
Flowers not in umbels.
Carpel solitary.
Petals strap-shaped, reflexed . . *Alangiaceæ.* 116.
Petals oblong.
Leaves balsamic . . . . . *Anacardiaceæ.* 76.
Leaves insipid.
Cotyledons convolute . . . *Combretaceæ.* 114.
Cotyledons flat . . . . *Haloragaceæ.* 113.
Carpels 2 or more, divaricating at the apex.
Leaves alternate. Herbs . . . *Saxifragaceæ.* 85.
Leaves opposite. Shrubs . . . *Hydrangeaceæ.* 86.
Carpels 2 or more, not divaricating, combined.
Calyx valvate.
Stamens opposite to the petals, isomerous . . . . *Rhamnaceæ.* 75.
Stamens alternate with the petals if isomerous.
Albumen none. Ovules horizontal or ascending . . . . *Onagraceæ.* 112.
Albumen none. Ovules pendulous *Haloragaceæ.* 113.
Albumen abundant . . . *Cornaceæ.* 117.
Calyx not valvate.
Stamens doubled downwards. Anthers with appendages. Leaves ribbed . *Melastomaceæ.* 111.
Stamens only curved. Anthers short.
Leaves dotted . . . . . . *Myrtaceæ.* 106.
Leaves not dotted.
Seeds very numerous, minute . *Escalloniaceæ.* 104.
Seeds few . . . . . . *Bruniaceæ.* 119.
b. Leaves with stipules.
Placentas parietal.
Stipules cirrhose. Monopetalous . . *Cucurbitaceæ.* 99.
Stipules deciduous. Petals distinct . . *Homaliaceæ.* 101.
Placentas in the axis.
Stamens opposite to the petals, isomerous . *Rhamnaceæ.* 75.
Stamens if equal to the petals, alternate with them.
Leaves opposite . . . . . . *Rhizophoraceæ.* 115.
Leaves alternate . . . . . . *Hamamelidaceæ.* 118.

Although it generally happens that the Calycifloræ have dichlamydeous flowers, polypetalous corollas, and perigynous or epigynous stamens, yet several exceptions occur, which should

be particularly noted by the student. Thus, we find apetalous plants in the *Celastraceæ*, *Rhamnaceæ*, *Anacardiaceæ*, *Leguminosæ*, *Rosaceæ*, *Lythraceæ*, *Saxifragaceæ*, *Cunoniaceæ*, *Paronychiaceæ*, *Mesembryaceæ*, *Passifloraceæ*, *Myrtaceæ*, *Onagraceæ*, *Haloragaceæ*, *Combretaceæ*, *Hamamelidaceæ*, and *Araliaceæ*. Monopetalous corollas occur commonly in *Stackhousiaceæ*, *Papayaceæ*, *Cucurbitaceæ*, and *Belvisiaceæ*, and occasionally in *Crassulaceæ*, *Portulacaceæ*, *Lecythidacaceæ*, and *Araliaceæ*. In some calycifloral Exogens again, the stamens are wholly, or in part, hypogynous or nearly so, as in *Anacardiaceæ*, *Connaraceæ*, *Leguminosæ*, *Saxifragaceæ*, *Crassulaceæ*, *Francoaceæ*, *Paronychiaceæ*, and *Portulaceæ*.

Unisexual flowers always occur in *Hensloviaceæ*, *Papayaceæ*, *Pangiaceæ*, and *Cucurbitaceæ*, and sometimes in *Rosaceæ*, *Hydrangeaceæ*, *Passifloraceæ*, *Grossulariaceæ*, *Haloragaceæ*, *Combretaceæ*, *Cornaceæ*, *Hamamelidaceæ*, and *Araliaceæ*.

Exceptions also not unfrequently occur to the characters commonly found in the perigynous and epigynous subdivisions of the Calycifloræ. Thus, in the Perigynæ we sometimes find the ovary partially or wholly inferior instead of superior, as in *Vochysiaceæ*, *Rhamnaceæ*, *Anacardiaceæ*, *Rosaceæ*, *Saxifragaceæ*, *Hydrangeaceæ*, *Cunoniaceæ*, *Portulacaceæ*, and *Mesembryaceæ*. The exceptions to the ordinary inferior ovary of the Epigynæ are much more rare, only commonly occurring in *Myrtaceæ*, *Melastomaceæ*, and *Bruniaceæ*, where the ovary is sometimes partially or wholly superior.

Sub-class 3.—*Corollifloræ.*

1. Epigynæ.

The Natural Orders placed in this sub-division were included by De Candolle in the Calycifloræ; the Corollifloræ being restricted by him to those monopetalous orders in which the corolla was hypogynous, and the ovary consequently superior, and which are placed in our arrangement in the sub-divisions Hypostamineæ and Epipetalæ. The simplest arrangement, however, for the student is, to consider the Monopetalous Corolla as the essential mark of the Corollifloræ, and in accordance with this view we place this sub-division here. It should be noticed, however, that some monopetalous orders have been placed by us in the Calycifloræ. (See p. 567.)

Natural Order 122.—Caprifoliaceæ.—The Honeysuckle Order.—General Character.—Shrubs, or rarely herbs. *Leaves* opposite (*fig.* 262), exstipulate. *Calyx* superior (*fig.* 942), 4—5-cleft, usually bracteated. *Corolla* monopetalous (*fig.* 943), 4—5-cleft, tubular or rotate (*fig.* 943), regular (*fig.* 943),

or irregular, rarely polypetalous. *Stamens* (*fig.* 943), 4—5, inserted on the corolla, and alternate with its lobes *Ovary* in-

Fig. 942.

Fig. 943.

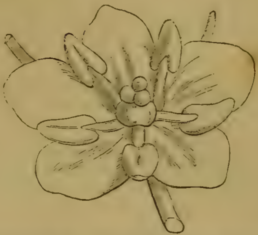


Fig. 944.

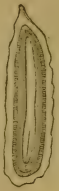


Fig. 942. Pistil of the Common Elder (*Sambucus nigra*), surrounded by a superior 5-lobed calyx.——*Fig.* 943. Entire flower of the Elder.——*Fig.* 944. Vertical section of the seed.

ferior (*figs.* 942 and 943), 1—5-celled, usually 3-celled, often with 1 ovule in one cell, and several in the others; *style* 1, or none (*fig.* 943); *stigmas* 1—3 (*fig.* 943), or 5. *Fruit* indehiscent, 1 or more celled, dry or succulent, and crowned by the persistent calycine lobes. *Seeds* solitary or numerous; *embryo* small (*fig.* 944), in fleshy albumen.

Diagnosis.—Shrubs or herbs, with opposite exstipulate leaves. *Calyx* superior, 4—5-cleft, persistent. *Corolla* monopetalous, and bearing commonly as many stamens as it has lobes, to which they are alternate, regular or irregular. Ovary inferior, 1—5-celled. Fruit indehiscent. Seeds with fleshy albumen.

Distribution, &c.—Chiefly natives of the northern parts of Europe, Asia, and America. They are rare in the southern hemisphere. *Examples:*—Linnæa, Symphoricarpus, Leycesteria, Caprifolium, Lonicera, Viburnum, Sambucus. There are 16 genera, and about 220 species.

Properties and Uses.—The plants of this order have frequently showy flowers, which are also commonly sweet-scented; hence many are cultivated in our gardens and shrubberies, as Honeysuckles, which are species of *Caprifolium* and *Lonicera;* Guelder Roses (*Viburnum* species), Laurustinus (*Viburnum Tinus*), Snowberry (*Symphoricarpus racemosus*), &c. Some are emetics and mild purgatives; others are astringent; others sudorific and diuretic; and some are acrid.

Triosteum perfoliatum is a mild purgative and emetic. Its roasted seeds have been used as a substitute for coffee.

Viburnum.—*V. Lantana*, the Mealy Guelder-rose, or Wayfaring Tree, has a very acrid inner bark. It is sometimes considered as a vesicant. *V. Opulus*, the Guelder-rose, is commonly regarded as emetic and cathartic. *V. cassinoides.*—The leaves of this plant, mixed with those of *Prinos glaber* (*Aqui-*

foliaceæ), are employed in N. America as a substitute for Tea, under the name of Appalachian Tea (see *Prinos*).

Sambucus nigra, the Common Elder. — Several parts of this plant have been long employed in medicine. Its flowers contain a volatile oil, which renders them mildly stimulant and sudorific. They are chiefly used in the formation of a cooling ointment, and in the preparation of Elder Flower Water. The inner bark and the leaves, have more or less purgative and emetic properties. The fruit is also mildly aperient and diuretic. It is extensively used for the purpose of adulterating Port-wine, and in the manufacture of a kind of wine, which is commonly known as Elder Wine.

Natural Order 123. — CINCHONACEÆ. — The Cinchona Order. General Character.—Trees, shrubs, or herbs. *Leaves* simple (*fig.* 359), entire, opposite, with interpetiolar stipules. *Inflorescence* cymose. *Calyx* superior, with the limb 4—6-toothed, or entire. *Corolla* monopetalous, regular, tubular, with its lobes corresponding in number to the teeth of the calyx. *Stamens* inserted upon the corolla, and equal in number to its lobes, with which they are alternate. *Ovary* inferior, crowned by a disk, usually 2-celled, or sometimes many-celled; *style* 1, sometimes slightly divided; *stigma* simple or divided. *Fruit* inferior, many-celled, or usually 2-celled, dry or succulent, indehiscent, or separating into 2 dry cocci. *Seeds* 1, 2 or more in each cell, when few, they are erect or ascending, or when numerous, then attached to axile placentas; *embryo* small, in horny albumen.

Diagnosis. — Trees, shrubs, or herbs, with opposite, simple, entire leaves, and interpetiolar stipules. Calyx superior. Corolla regular. Stamens equal in number to the teeth of the calyx and segments of the corolla, with the latter of which they are alternate, epipetalous. Ovary inferior, 2 or more celled. Fruit inferior. Seeds 1 or more, with horny albumen.

Division of the Order, &c. — The Cinchonaceæ may be divided into two sub-orders as follows: —

Sub-order 1. *Coffeæ.*—Ovary with 1 or 2 seeds only in each cell. *Examples:* — Pomax, Coprosma, Richardsonia, Cephaëlis, Psychotria, Coffea, Ixora, Morinda, Guettarda.

Sub-order 2. *Cinchoneæ.* — Ovary many-seeded. *Examples:* — Rondeletia, Exostemma, Cinchona, Nauclea, Gardenia, Genipa.

Distribution, &c. — They are almost exclusively natives of tropical and warm regions. There are 318 genera, and about 2550 species.

Properties and Uses. — The properties of the plants of this extensive order are very important to man, furnishing him with many valuable medicinal agents, as well as substances useful in the arts and domestic economy. Thus, many possess tonic, febrifugal, astringent, emetic, or purgative properties; a few are valuable dyeing and tanning agents, and others have edible fruits and seeds. A few are reputed to have intoxicating, and in some cases, even poisonous properties. Various species are

also cultivated in our stoves on account of the beauty and fragrance of their flowers.

Coprosma microphylla.—The fruits of this and other species are eaten in Australia, where they are called Native Currants.

Richardsonia scabra or *braziliensis.*— The root is emetic. It contains the same active principle, namely, *emetina*, as that of the *annulated ipecacuanha* root from *Cephaëlis Ipecacuanha* (see below), but it is not so active as it. It is commonly known as *undulated, white*, or *amylaceous ipecacuanha.* It is not used in this country.

Cephaëlis Ipecacuanha.— The root of this plant is termed *annulated ipecacuanha* (*fig.* 247). It is the officinal Ipecacuanha of this country. It contains an alkaloid called *emetina*, to which its properties are principally due. It possesses emetic and purgative properties in large doses, and in small doses it is expectorant and diaphoretic. It is also sedative.

Psychotria emetica.—Its root is called *black* or *striated ipecacuanha.* It is not used in this country, but it possesses emetic properties like the roots of the two preceding plants, although less active than the annulated ipecacuanha. It contains *emetina.* The roasted seeds of *P. herbacea* have been used as a substitute for coffee.

Coffea arabica, the Coffee Plant. — The seeds of this plant when roasted, are used in the preparation of that most valuable beverage—*coffee.* Coffee owes its properties chiefly to the presence of *caffeine*, which is identical with *theine*, (see *Thea*, p. 476), and a volatile oil. About 40 millions of pounds are annually consumed in this country, and the consumption for the whole world has been estimated at about 600 millions of pounds. In Sumatra and some of the adjoining islands, an infusion of the roasted leaf is used as a substitute for tea, hence this is called Coffee-Tea. The leaf contains similar ingredients to the seeds, and possesses therefore analogous properties.

Morinda citrifolia.—The roots of this species, as well as those of *M. tinctoria*, are used in India and some other parts of Asia, for dyeing red. They have been occasionally imported into this country, under the names of Madder, Munjeet, and Chay-root ; but such names are improperly applied to this substance. (See *Oldenlandia* p. 571, and *Rubia* p. 572.)

Guettarda speciosa.—The wood of this plant is imported from the West Indies. It is the Zebra-Wood of cabinet-makers. *Tortoise-wood* is also sometimes considered to be the produce of a variety of the same tree.

Oldenlandia umbellata.—The root of this plant is occasionally imported from India under the name of *Chay* or *Che* root. It is employed to dye red, purple, and orange-brown. The colouring matter is confined to the bark.

Cinchona.—The plants of this genus are natives exclusively of the intertropical valleys of the Andes, and principally on the eastern face of the Cordilleras, growing commonly at heights varying from about 4000 to nearly 12,000 feet above the level of the sea. The Cinchona region extends from Santa Cruz de la Sierra, in Bolivia, about 19° S. lat., through Peru and Columbia, nearly to Caracas, in about 10° of N. lat. They are small shrubs, or large forest trees, with evergreen leaves, and commonly showy flowers. They appear to require great moisture, and a mean temperature of about 62°. The barks of several species and varieties are extensively imported into this country, under the names of *Cinchona*, *Peruvian*, or *Jesuits'* Bark. Twenty-six varieties have been described by Pereira, and Weddell has enumerated no less than 39. The more important are *Loxa* or *Crown Bark ; Gray*, *Silver*, or *Huanuco Bark ; Yellow Bark ;* and *Red Bark.* These four are officinal in our Pharmacopœias. The different sorts of *Loxa* or *Crown Bark*, appear to be derived as follows : — Original or True Crown, from *C. Condaminea*, var. *vera*, of Weddell, now termed *C. crispa ;* White Crown, from *C. Condaminea*, var. *lucumæfolia ;* the H. O. Crown Bark, according to Mr. Howard, from *C. glandulifera ;* Ashy Crown, from *C. Condaminea*, var. *rotundifolia ;* and Wiry Loxa, from *C. hirsuta.* All the above sorts are known in commerce, under the names of Loxa or Crown barks. Fine Gray Bark is the produce of *C. nitida*, and the inferior or coarser kind, of *C. micrantha.* They are usually mixed together. The genuine Calisaya or Yellow Bark, is the produce of *C. Calisaya*, var. *vera.* Two other kinds of barks are sold as true Calisaya, namely, Josephian Calisaya, from *C. Calisaya*, var. *Josephiana*, and Bolivian Mulberry Calisaya, from *C. Boliviana.* Several *spurious* or *false Calisayas*, are also known. The origin of Red Bark is not altogether ascertained ; but it would appear

from the recent researches of Mr. Howard, to be derived from *C. erythroderma*, or *Cinchona ovata*, var. *erythroderma*, now termed *C. succirubra*. Inferior kinds of barks are, Carabaya Bark, from *C. ovata*, var. *vulgaris;* Cusco Bark, from *C. pubescens*, var. *Pelletieriana;* Huamalies, or Rusty Bark, from *C. Condaminea*, var. *Chahuarguera;* Coquetta or Bogota Bark, and Fibrous Carthagena, from *C. Condaminea*, var. *lancifolia;* Hard Carthagena, from *C. cordifolia*, var. *vera*, &c. &c. Several alkaloids have been described as constituents of the Cinchona barks, but by far the most important are, *Quina*, *Cinchonia*, and *Quinidia*. These are all used in medicine, and possess in an eminent degree, tonic, febrifuge, and antiperiodic properties. The barks themselves, in addition to such properties, are also slightly astringent.

Uncaria or *Nauclea Gambir*.—An extract prepared from the leaves of this plant, constitutes the kind of Catechu, which is known in commerce as *Gambir* or *Gambier*, or *Pale Terra Japonica*, and by druggists, as *Catechu in square cakes*. It is one of the most powerful of astringents, and is largely employed in tanning and dyeing, and also in medicine.

Sarcocephalus esculentus.—The fruit is the Sierra Leone Peach.

Genipa.—The fruit of some species is eatable, that of *G. americana*, the Lana tree, is the *Genipap* of South America. In British Guiana, a bluish-black dye called Lana dye, is prepared from the juice of the fruit.

Gardenia.—From the fruits of *G. grandiflora*, *G. florida*, and *G. radicans*, beautiful yellow dyes are prepared, which are extensively used in China and Japan.

Natural Order 124.—GALIACEÆ or STELLATÆ.—The Madder Order.—Herbaceous plants, with whorled exstipulate leaves (*fig.* 263), and angular stems (*fig.* 263). *Calyx* superior (*figs.* 946 *cal*, and 947 *b*), with the limb 4–6-lobed, or obsolete. *Corolla* monopetalous, 4—6-lobed (*fig.* 945), regular.

Fig. 945.

Fig. 946.

Fig. 947.

Fig. 948.

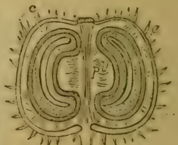


Fig. 945. Diagram of the flower of the Madder (*Rubia tinctorum*).——*Fig.* 946. Pistil of Madder adherent to the calyx, *cal*. *st*. Styles and stigmas. *Fig.* 947. Pistil of Goose Grass or Cleavers (*Galium Aparine*), surrounded by calyx, *b*. *st*. Styles.——*Fig.* 948. Vertical section of the fruit of *Galium Aparine*. *a*. Albumen. *c*. Embryo. *pl*. Placenta.

Stamens epipetalous, equal in number to the lobes of the corolla, and alternate with them (*fig.* 945). *Ovary* inferior (*figs.* 946 and 947), 2-celled (*fig.* 945), with one solitary erect ovule in each cell; *styles* 2 (*figs.* 946 and 947 *st*). *Fruit* 2-celled, indehiscent, with 1 erect seed in each cell (*fig.* 948); *albumen* horny (*fig.* 948 *a*). This order is generally included with the Cinchonaceæ in a common order, called Rubiaceæ. The Galiaceæ are at once distinguished from the Cinchonaceæ by their whorled exstipulate leaves, and angular stems. Some regard the whorls

as formed partly of leaves, and partly of stipules resembling the true leaves in form and appearance. The above arrangement of the Cinchonaceæ and Galiaceæ is in accordance with the views of Lindley.

Distribution, &c. — The plants of this order are common weeds in the northern parts of the northern hemisphere. They are also found inhabiting high mountainous districts in Peru, Chili, and Australia. *Examples:* — Galium, Rubia, Asperula, Sherardia. There 10 genera, and 320 species.

Properties and Uses. — They are chiefly remarkable for the presence of a colouring matter in their roots, and hence are used in dyeing. Some are reputed to possess tonic, diuretic, and emmenagogue properties, and the roasted seeds of certain species have been employed as substitutes for coffee.

Galium Aparine, Goose-grass, or Cleavers. — The inspissated juice or extract of this plant, has been used with success in *lepra* and some other cutaneous diseases. Its roasted seeds have been employed as a substitute for coffee. The extract of *G. rigidum*, and *G. Mollugo*, have been employed in epilepsy.

Rubia tinctorum.— The root of this plant is known under the name of Madder, and is one of the most important of dyes. It is largely cultivated in France, Holland, the Levant, &c. Madder is imported in two forms, namely, in the entire root, and in a ground state. There are four kinds of Dutch Madder, known respectively as *crops* (the best), *ombro*, *gamene*, and *mull* (the worst). In the living state, madder-root only contains a yellow colouring principle, but no less than five colouring matters have been obtained from the madder of commerce, called respectively *madder purple* (*purpurine*), *red* (*alizarine*), *orange*, *yellow*, and *brown*. It would appear, therefore, that these must be all derived from the single yellow colouring principle. Besides its use as a dyeing material, madder was long employed in medicine as a tonic and diuretic, and has been regarded as a valuable emmenagogue. Besides the roots of *R. tinctorum*, those of other species are employed in different parts of the world for dyeing: thus, the roots of *R. cordifolia* or *munjista*, a native of the East Indies, are used in Bengal, &c., as madder; and are occasionally imported into this country under the name of *munjeet*. The roots of *R. Relboun* are also employed in Chili for dyeing.

Natural Order 125. Columelliaceæ. — The Columellia Order. — Evergreen shrubs or trees. *Leaves* opposite, exstipulate. Flowers unsymmetrical, yellow, terminal. *Calyx* superior, 5-parted. *Corolla* monopetalous, rotate, 5—8-parted, imbricated. *Stamens* 2, epipetalous; *anthers* sinuous, with longitudinal dehiscence. *Ovary* inferior, 2-celled, surmounted by a fleshy disk. *Fruit* a 2-celled, many-seeded capsule. *Seeds* with fleshy albumen.

Distribution, &c. — Natives of Mexico and Peru. It only contains the genus *Columellia*, which includes 3 species.

Properties and Uses. — Unknown.

Natural Order 126. Valerianaceæ. — The Valerian Order. — Herbs. *Leaves* opposite, exstipulate. *Flowers* cymose, hermaphrodite (*figs.* 480 and 481), or rarely unisexual. *Calyx* superior (*fig.* 949 *ca*), with the limb obsolete, or membranous, or pappose. *Corolla* monopetalous (*figs.* 480 and 481), tubular, imbricated, 3—6-lobed, regular or irregular, sometimes spurred

at the base (*fig.* 481). *Stamens* 1—5, inserted upon the corolla (*figs.* 480 and 481). *Ovary* inferior (*figs.* 480, 481, and 949), with 1 fertile cell, and usually 2 abortive or empty ones. *Fruit* dry and indehiscent, frequently pappose (*fig.* 452). *Seed* (*fig.* 949) solitary, pendulous, exalbuminous ; *radicle* superior.

Distribution, &c.—Chiefly natives of the temperate parts of Europe, Asia, and America ; they are rare in Africa. *Examples :* —Nardostachys, Valerianella, Centranthus, Valeriana. There are 12 genera, and 185 species.

Properties and Uses.—They are chiefly remarkable for the presence of a strong-scented volatile oil, which renders them stimulant, antispasmodic, and tonic. Some are highly esteemed in the East as perfumes, but they are not generally considered agreeable by Europeans.

Nardostachys Jatamansi is the true Spikenard of the ancients. It is much esteemed in India both as a perfume, and as a remedial agent in epilepsy and hysteria. It is the *Nard* of the Hebrews, and the *Nardos* of the Greeks. The root is supposed to be the Sumbul of the shops (see Sumbul, p. 562).

Valerianella olitoria.—The young leaves are occasionally used as a salad, both on the continent and in England. In France they are known under the name of *mâche*, and in England by that of *Lamb's Lettuce.*

Valeriana officinalis.—The root of this plant is the officinal Valerian of the British Pharmacopœias. It is much employed as a nervous excitant and antispasmodic. The roots of *V. Dioscoridis*, *Phu. celtica*, *sitchensis*, and other species, have similar properties. *V. sitchensis* is most esteemed in Russia.

Natural Order 127. DIPSACACEÆ.—The Teazel Order.—Herbs or undershrubs. *Leaves* opposite, or verticillate, exstipulate. *Flowers* in dense heads (capitula) (*fig.* 405), sur-

Fig. 949.

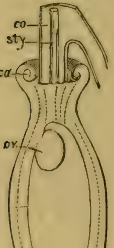


Fig. 950.

Fig. 951.

Fig. 949. Vertical section of the ovary of the Red Valerian (*Centranthus ruber*). *ca.* Calyx. *co.* Corolla. *sty.* Style. *ov.* Ovule.——*Fig.* 950. Fruit of *Scabiosa purpurea*, surmounted by the pappose calyx.——*Fig.* 951. One of the central florets of the capitulum of *Scabiosa purpurea*, with the ovary, &c., cut vertically.

rounded by an involucre. *Calyx* (*fig.* 951) superior, with a membranous or pappose limb, and surrounded by an involucel. *Corolla* (*fig.* 951) tubular, monopetalous, the limb 4—5-lobed, generally irregular (*fig.* 405), and with an imbricated æstivation. *Stamens* 4 epipetalous (*fig.* 951); *anthers* distinct. *Ovary* inferior (*fig.* 951), 1-celled; *ovules* solitary, pendulous; *style* and *stigma* simple. *Fruit* dry, indehiscent, surmounted by the pappus-like calyx (*figs.* 453 and 950). *Seed* with fleshy albumen, and having a straight embryo, and a superior radicle.

Distribution, &c.—Chiefly natives of the south of Europe, and of North and South Africa. A few species are found in this country. *Examples:* — Dipsacus, Knautia, Scabiosa. There are 6 genera, and 150 species.

Properties and Uses.—Some are reputed to possess astringent and febrifugal properties, but as remedial agents they are altogether unimportant.

Dipsacus Fullonum, Fuller's Teazel. — The dried capitula are used by fullers in dressing cloth, for which they are well adapted, as their hard, stiff, hooked bracts, raise the nap, without tearing the stuff like metal instruments.

Scabiosa succisa, is called the Devil's-bit Scabious, on account of its abruptly terminated root (*fig.* 253). It is said to be astringent, and to yield a green dye. The inflorescence sometimes developes in an umbellate manner, as in a specimen described by the Author, in the *Pharmaceutical Journal*, vol. xvii., p. 363, thus exhibiting a marked deviation from the development in capitula, which is the ordinary arrangement in the plants of this order.

Natural Order 128. CALYCERACEÆ.—The Calycera Order.—Herbs. *Leaves* alternate, exstipulate. *Flowers* in capitula, surrounded by an involucre. *Calyx* superior, irregular 5-lobed. *Corolla* monopetalous, regular, valvate, 5-lobed. *Stamens* 5, epipetalous; *filaments* monadelphous; *anthers* partially united. *Ovary* inferior, 1-celled, with a solitary pendulous ovule. *Fruit* indehiscent. *Seed* solitary, pendulous, with fleshy albumen, and a superior radicle. They hold an intermediate position between Dipsacaceæ and Compositæ, being distinguished from the former by their alternate leaves, absence of involucel to their individual florets, valvate æstivation of corolla, monadelphous filaments, and partially united anthers: and from the Compositæ in their anthers being only partially united, and in their pendulous albuminous seed and superior radicle.

Distribution, &c. — Exclusively natives of South America, especially the cooler parts. *Examples:* — Boopis, Calycera, Leucocarpus. There are 8 genera belonging to the order.

Properties and Uses. — Unknown.

Natural Order 129. COMPOSITÆ or ASTERACEÆ.—The Composite Order. — General Character. — Herbs or shrubs. *Leaves* alternate or opposite, exstipulate. *Flowers* (florets) hermaphrodite (*figs.* 952—954), or unisexual (*fig.* 477), arranged in capitula (*figs.* 404 and 420), which are surrounded by an involucre formed of a number of imbricated bracts (*phyllaries*) (*fig.* 376); the separate florets are also frequently furnished

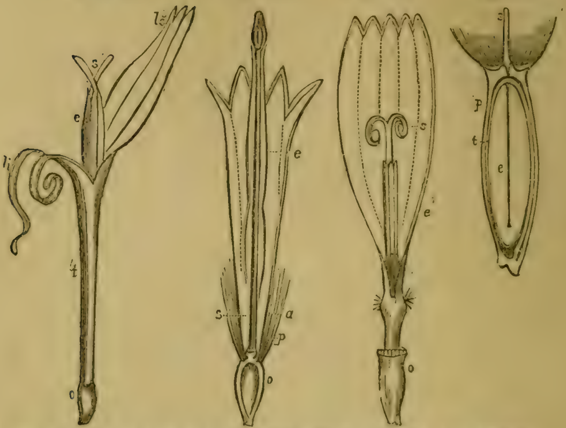


Fig. 952. Labiate floret of *Chætanthera linearis*. *o.* Ovary with adherent calyx. *t.* Tube of the corolla. *l s.* Upper lip of corolla, *l i.* Lower lip. *e.* Tube formed by the adherent anthers. *s.* Stigmas.——*Fig.* 953. Vertical section of the floret of *Aster rubricaulis*. *o.* Erect ovule, enclosed in the inferior ovary. *a.* Limb of the calyx. *p.* Corolla. *s.* Style. *e.* Tube of the anthers.——*Fig.* 954. Floret of the Chicory (*Cichorium Intybus*). *o.* Ovary with adherent calyx. *e. Tube* formed by the adherent anthers. *s.* Stigmas.——*Fig.* 955. Vertical section of the ripe fruit of a Groundsel (*Senecio*), surmounted by a portion of the style, *s*; and the hairy limb of the calyx. *p.* Pericarp *t.* Testa. *e.* Seed. The above figures are from Jussieu.

with membranous scale-like bractlets (called *paleæ*) (*fig.* 381). *Calyx* superior (*figs.* 952—954), its limb either entirely abortive (*fig.* 450), or membranous (*fig.* 451), and then entire or toothed; or pappose,—that is, divided into bristles, or simple, or branched, or feathery hairs (*fig.* 953). *Corolla* monopetalous (*figs.* 952—954), tubular (*fig.* 451), ligulate (*fig.* 954), or bilabiate (*fig.* 952), 4—5-toothed, with a valvate æstivation. *Stamens* (*figs.* 952—954 *e*) 5, or rarely 4, inserted on the corolla, and alternate with its divisions; *filaments* distinct or monadelphous; *anthers* united into a tube (*syngenesious* or *synantherous*) (*fig.* 536), which is perforated by the style (*fig.* 954). *Ovary* inferior, 1-celled, with 1 erect ovule (*fig.* 953): *style* 1, undivided below, and commonly bifid above (*fig.* 956): *stigmas* 2, one being placed on the inner surface of each division of the style (*fig.* 956). *Fruit* dry, indehiscent, 1-celled, (called a *cypsela*), crowned by the limb of the calyx which is often pappose (*fig.* 955). *Seed* (*fig.* 955) solitary, erect, exalbuminous; *radicle*, inferior (*fig.* 955 *e*).

Fig. 956.

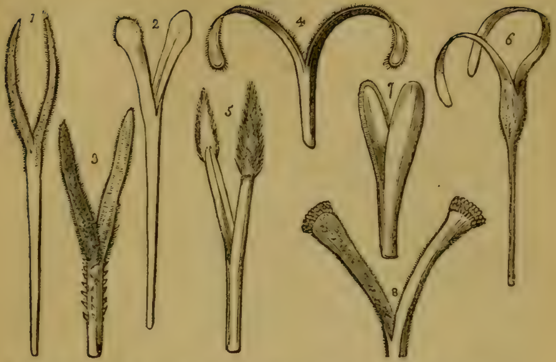


Fig. 956. Styles and stigmas of Composite Flowers to illustrate De Candolle's tribes, after Heyland and Lindley. 1. *Albertinia erythropappa* (Vernonieæ). 2. *Anisochœta mikanioides* (Eupatorieæ). 3. *Blumea senecioides* (Asteroideæ). 4. *Mendezia bicolor* (Senecioideæ). 5. *Lipochœta umbellata* (Senecioideæ). 6. *Aplotaxis nepalensis* (Cynareæ). 7. *Leucomeris spectabilis* (Mutisieæ). 8. *Leuceria tenuis* (Nassavieæ).

Diagnosis.—Herbs or shrubs, with exstipulate leaves. Flowers (called florets) arranged in dense capitula, and surrounded by an involucre. Calyx superior, its limb abortive, or membranous, or pappose. Corolla monopetalous, 4—5-toothed. Stamens epipetalous, equal in number to the divisions of the corolla (generally 5), and alternate with them ; anthers syngenesious. Ovary inferior, 1-celled with 1 erect ovule, style simple, bifid above. Fruit 1-celled, dry, indehiscent. Seed solitary, erect, exalbuminous ; radicle inferior.

Division of the Order, &c. — This order has been differently divided by authors. By Linnæus, the plants of his class *Syngenesia*, division *Polygamia*, (which corresponded to the Natural Order *Compositæ* as above defined,) were divided into five orders, under the names of Polygamia Æqualis, Superflua, Frustanea, Necessaria, and Segregata. The characters of these have been already stated at page 412. Jussieu separated the Compositæ into three sub-orders as follows:—1. *Corymbiferæ*, the plants of which have all tubular (flosculous) and perfect florets; or those of the disk (centre) are tubular and perfect, and those of the ray (circumference) tubular and pistilliferous, or ligulate (radiant). 2. *Cynarocephalæ*, the florets of which are all tubular and perfect; or those in the centre are perfect, and those of the ray neuter : and 3. *Cichoraceæ*, having all the florets ligulate and perfect. A fourth sub-order was afterwards added, called

Labiatifloræ, which included those plants the florets of which were bilabiate; this group was unknown to Jussieu. The arrangement most frequently adopted at the present day, is that of De Candolle, which was founded on that of Lessing. It is as follows: —

Sub-order 1. *Tubulifloræ.*—Florets tubular or ligulate, either perfect, unisexual, or neuter. Perfect florets tubular, with 5, or rarely 4, equal teeth. This sub-order includes the *Corymbiferæ* and *Cynarocephalæ* of Jussieu. It has been divided into five tribes: —

Tribe 1. *Vernonieæ.* Style cylindrical; its arms generally long and subulate, sometimes short and blunt, always covered all over with bristles, (*fig.* 956, 1). *Examples*:—Adenocyclus, Vernonia, Elephantopus.

Tribe 2. *Eupatorieæ.* Style cylindrical; its arms long and somewhat clavate, with a papillose surface on the outside near the end (*fig.* 956, 2.) *Examples*:—Eupatorium, Ageratum, Tussilago, Petasites.

Tribe 3. *Asteroideæ.* Style cylindrical; its arms linear, flat on the outside, equally and finely downy on the inside, (*fig.* 956, 3). *Examples*:—Erigeron, Bellis, Inula, Pulicaria.

Tribe 4. *Senecioideæ.* Style cylindrical; its arms linear, fringed at the point, generally truncate, but sometimes extended beyond the fringe into a short cone or appendage of some kind (*fig.* 956, 4 and 5). *Examples*:—Anthemis, Anacyclus, Artemisia, Tanacetum, Arnica, Senecio.

The above four tribes correspond to the sub-order *Corymbiferæ* of Jussieu; the next tribe to the *Cynarocephalæ* of the same author.

Tribe 5. *Cynareæ.* Style thickened above, and often with a bunch or fringe of hairs at the tumour; its branches united or free, (*fig.* 956, 6). *Examples*: — Calendula, Echinops, Arctium, Carlina, Centaurea, Cnicus, Carthamus, Cynara.

Sub-order 2. *Labiatifloræ.* — Hermaphrodite florets, or at least the unisexual ones, divided into two lips. Of this sub-order we have two tribes:—

Tribe 6. *Mutisieæ.* Style cylindrical or somewhat swollen; its arms usually blunt or truncate, very convex on the outside and covered at the upper part by a fine uniform hairiness or absolutely free from hairs (*fig.* 956, 7). *Examples*: — Barnadesia, Mutisia, Printzia.

Tribe 7. *Nassavieæ.* Style never swollen; its arms long, linear, truncate, and fringed only at the point (*fig.* 956, 8). *Examples*:—Nassavia, Anandria, Trixis.

Sub-order 3. *Ligulifloræ.* Florets all ligulate and perfect. This corresponds to the *Cichoraceæ* of Jussieu.

Tribe 8. *Cichoreæ.* Style cylindrical at the upper part; its

arms somewhat obtuse, and equally pubescent (*fig.* 476). *Examples:*—Cichorium, Scorzonera, Tragopogon, Lactuca, Taraxacum, Hieracium.

Distribution, &c. — Universally distributed; but the *Tubulifloræ* are most abundant in hot climates, and the *Liguliforæ* in cold. The *Labiatifloræ* are almost confined to the extra-tropical parts of South America. In the Northern parts of the world the plants of this order are universally herbaceous; but in South America and some other parts of the southern hemisphere, they sometimes become shrubby, or even occasionally arborescent. There are about 9500 species, according to M. Lasègue, who remarks "that they have steadily continued to constitute about $\frac{1}{10}$ of all described plants, in proportion as our knowledge of species has advanced. Thus Linnæus had 785 Composites out of 8500 species; in 1809 the proportion was 2800 to 27,000; De Candolle described 8523 in the year 1838, which was again a tenth; and now (1845), that the estimate of species has risen to 95,000, Composite plants amount to 9500." According to Lindley, there are about 1080 genera, and 9000(?) species.

Properties and Uses. — The properties of the *Compositæ* are variable. A bitter principle pervades the greater number of the species in a more or less evident degree, by which they are rendered tonic. Some are laxative and anthelmintic. Many contain a volatile oil, which communicates aromatic, carminative, and diaphoretic properties. Others are acrid stimulants, and the *Liguliforæ* commonly abound in a bitter-tasted milky juice, which is sometimes narcotic.

Sub-Order 1. TUBULIFLORÆ.— The plants of this sub-order are chiefly remarkable for their bitter, tonic, and aromatic properties; these are due to the presence of a bitter principle, and a volatile oil. Some are esculent vegetables.

Vernonia anthelmintica. — The fruit of this plant is used in the East Indies as an anthelmintic.

Eupatorium glutinosum. — According to Hartweg, the leaves of this plant constitute the substance called Matico, which is employed as a styptic. The matico used in this country is, however, derived from *Artanthe elongata*, a plant of the Nat Ord. Piperaceæ. *E. ayapana* and *E. perfoliatum* have been employed as antidotes to the bites of venomous reptiles.

Mikania Guaco and *opifera* have been much used as antidotes to the bites of venomous serpents in South America.

Tussilago Farfara, Coltsfoot. — This plant is employed as a popular remedy in chronic coughs and other pulmonary complaints.

Inula Helenium, Elecampane, is an aromatic tonic, expectorant, and diaphoretic. It has been employed in chronic catarrh, and in dyspepsia.

Guizotia oleifera, (*Verbesina sativa*) of Lessing, is extensively cultivated in India for its seeds, which are known in commerce under the name of Niger Seeds. These yield a very thin oil, useful in painting and for other purposes. It is known in India as Ram-til, Kala-til, Noog, &c.

Helianthus tuberosus. — The tubers are much eaten under the name of Jerusalem Artichokes. The dried fruits have been used as a substitute for coffee. *H. annuus* is the common Sunflower. The pith contains nitrate of potash, and is therefore sometimes used in the preparation of *moxas* in Europe. The fruits have been lately employed as an ingredient in a kind of soap called Sunflower Soap.

Anthemis nobilis, Chamomile or Camomile. — This plant is extensively cultivated for the sake of its flowers, which are much employed for their sti-

mulant tonic, and antispasmodic properties, and also externally for fomentations. The flowers constitute the Roman or True Chamomiles of the Materia Medica.

Matricaria Chamomilla has similar properties to the above. The flowers are the *Flores Chamomillæ* of German pharmacologists. The flowers are commonly distinguished as Common Chamomiles.

Anacyclus Pyrethrum, Pellitory of Spain. — The root is employed as an energetic local irritant, and sialogogue, in toothache, relaxation of the uvula, &c. *A. officinarum* of Hayne, has similar properties. The root is that commonly used in Germany.

Artemisia Absinthium. — The dried herb, or the flowering top, under the name of *Wormwood*, is used as an aromatic bitter tonic, and as an anthelmintic. It is also employed in the preparation of *some liqueurs*. *A. chinensis.* — According to Lindley, the *Chinese* and *Japanese Moxa* is prepared from the cottony or woolly covering of the leaves of this and other species. The substance sold as *Wormseed* consists of the broken flower-stalks, involucres, and flower-buds of several species of *Artemisia*, as *A. Sieberi*, *A. Vahliana*, *A. pauciflora*, *A. Lercheana*, *&c.* Wormseed is also known by the names of *semen-contra*, *semen cinæ*, *semen santonicum*, *&c.* It is employed as a vermifuge. *A. Dracunculus*, is the Tarragon, the leaves of which are sometimes used in pickles, salads, &c.

Tanacetum vulgare, the common Tansy, possesses tonic and anthelmintic properties.

Arnica montana, Mountain Arnica, Mountain Tobacco, or Leopard's-bane is an acrid stimulant. It has been employed in typhoid fevers, in amaurosis, in paralysis, &c. It has been named on the continent *Panacea lapsorum* from the power it possesses of absorbing tumours and destroying the effects of bruises.

Calendula officinalis, the Marigold, has yellow florets, which are sometimes employed to adulterate saffron.

Aucklandia Costus. — The root of this plant, which is a native of Cashmere, is said by Falconer to be the Costus of the ancients. It is commonly known in the North-Western parts of India under the name of Orris Root.

Carduus, the Thistle. — Some species of this genus, particularly *C. Benedictus*, have been used as tonics and febrifuges.

Onopordum Acanthium is the Scotch Thistle of gardeners. It is also known under the name of Cotton Thistle.

Carthamus tinctorius, Safflower or Bastard Saffron. — The florets are used in the preparation of a beautiful pink dye. The *pink saucers* of the shops are coloured by it. It is also largely employed in the manufacture of *rouge*. Safflower is sometimes used to adulterate hay saffron. The substance called *cake saffron* is prepared from it and mucilage. The fruits, which are commonly called seeds, yield by expression a large quantity of oil, which is known in India under the name of *Koosum Oil*. The fruits of *C. persicus* also yield a useful oil.

Cynara Scolymus. — The young succulent receptacles of this plant are used for food, under the name of Artichokes. The edible Cardoons are the blanched petioles and stems of *Cynara Cardunculus*.

Sub-Order 2. LABIATIFLORÆ. — There are no important plants known to belong to this sub-order. Some have been reputed aromatic, mucilaginous, and tonic, and the leaves of *Printzia aromatica* are sometimes employed at the Cape of Good Hope as a substitute for tea.

Sub-Order 3. LIGULIFLORÆ. — The plants of this sub-order generally contain a milky juice, which commonly possesses alterative, aperient, diuretic, or narcotic properties. The roots of some are used as esculent vegetables; and other plants of this division by cultivation with diminished light, become edible as salads.

Cichorium Intybus. Wild Succory or Chicory. — This plant is indigenous in this and many other countries of Europe. It is extensively cultivated for the sake of its roots, which are roasted and used as a substitute for, or more frequently as an addition to, ground coffee. Nearly 100 millions of pounds are annually consumed in Europe. It does not, however, possess in any degree, the peculiar exciting, soothing, and hunger staying properties of that substance, and its extensive employment is much to be deprecated as it is not unfrequently attended with injurious effects. The fresh root has been employed in medicine, and possesses somewhat similar properties to that of Dandelion. A blue dye may be prepared from the leaves. *Cichorium Endivia*

is the garden Succory or Endive, the leaves of which when blanched are used as a salad.

Scorzonera hispanica has esculent roots, which are known under the name of Scorzonera. The roots of *S. glastifolia*, *S. deliciosa*, and *S. tuberosa*, are also eaten in different parts of the world.

Tragopogon porrifolius. — The roots are eaten under the name of Salsafy. In America it is called the Oyster-plant, as the roots when cooked are thought to have the taste of Oysters.

Lactuca sativa is the garden or common Lettuce. It is largely cultivated as a salad. As a medicine it possesses anodyne, diaphoretic, and somewhat diuretic properties. *Lactuca virosa*, the Wild or Strong-scented Letture, possesses much more evident narcotic properties than the common Lettuce. The inspissated juice of both *L. sativa* and *L. virosa* is Lactucarium or Lettuce Opium, which is employed for its narcotic properties. *L. virosa* yields the best and the largest quantity of Lactucarium. Other species of *Lactuca* possess similar properties.

Taraxacum officinale or *Leontodon Taraxacum*, is the common Dandelion. The root is very extensively employed as a medicinal agent. It is commonly regarded as possessing aperient, diuretic, and alterative properties. It contains a bitter crystalline principle, called *Taraxacine*, to which it seems principally to owe its properties. When roasted, it is also sometimes employed as an addition to coffee in the same manner as Chicory root.

Natural Order 130. CAMPANULACEÆ.—The Hare-Bell or Bell-flower Order. — Herbaceous plants or under-shrubs, with a milky juice. *Leaves* nearly always alternate, exstipulate. *Calyx* superior (*figs.* 414 and 959), persistent (*fig.* 671 and 672) *Corolla*

Fig. 957. *Fig.* 958. *Fig.* 959.

Fig. 957. Diagram of the flower of Rampion (*Campanula Rapunculus*).—— *Fig.* 958. Vertical section of the seed.——*Fig.* 959. Vertical section of the flower of *Campnaula Rapunculus*.

monopetalous, regular (*figs.* 414 and 465), marcescent (*figs.* 414 and 672); *æstivation* valvate (*figs.* 414 and 957). *Stamens* equal in number to the lobes of the corolla (*fig.* 957), with which they are alternate; *anthers* (*fig.* 492) 2-celled, distinct or partly united. *Ovary* inferior (*figs.* 414 and 959), 2 or more-celled (*figs.* 615, 957 and 959); *style* simple (*fig.* 959), hairy (*fig.* 492); *stigma* naked (*fig.* 492). *Fruit* dry, capsular, dehiscing by lateral orifices (*figs.* 671 and 672), or by valves at the apex; *placenta* axile (*fig.* 615). *Seeds* numerous, with fleshy albumen (*fig.* 958).

Distribution, &c. — Chiefly natives of the temperate parts of the northern hemisphere; a good many are however found in

the southern hemisphere, especially at the Cape of Good Hope. A few species only are tropical. *Examples:*—Jasione, Wahlenbergia, Prismatocarpus, Phyteuma, Campanula, Specularia. There are 29 genera, and 500 species.

Properties and Uses.—The milky juice which they contain is sometimes of a sub-acrid character, but the roots and young parts of several species, especially when cultivated, are eaten in different parts of the world, as the roots of *Campanula Rapunculus*, commonly known under the name of Rampions; those of *Cyphia glandulifera* in Abyssinia; and those of *Cyphia digitata* by the Hottentots, &c. Some species of *Specularia* have been used in salads. One species, *Campanula glauca*, is reputed to be a valuable tonic, and others are said to be antisyphilitic. The order, however, does not contain a single plant of any particular importance, either in a medicinal or economical point of view.

Natural Order 131. LOBELIACEÆ.—The Lobelia Order.—Herbs or shrubs, with a milky juice. *Leaves* alternate, exstipulate. *Calyx* superior (*fig.* 961). *Corolla* monopetalous, irregular, valvate. *Stamens* 5, syngenesious (*fig.* 961). *Ovary* inferior (*fig.* 961), 1—3-celled; *placentas* axile or parietal; *style* 1 (*fig.* 961); *stigma* surrounded by a fringe of hairs (*fig.* 960). *Fruit* capsular, dehiscing at the apex. *Seeds* numerous, albuminous.

Fig. 961.

Fig. 960.

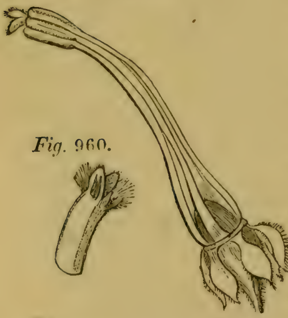


Fig. 960. Stigma of *Lobelia syphilitica*.——*Fig.* 961. The essential organs of the above, with the calyx.

Distribution, &c.—They are chiefly natives of tropical and sub-tropical regions; a few only occur in temperate and cold climates. *Examples:*—Clintonia, Lobelia, Tupa, Siphocampylus, Delissea. There are 29 genera, and 375 species.

Properties and Uses.—The milky juice with which they abound is commonly of a very acrid nature, hence the plants of the order should be regarded with suspicion, indeed some act as narcotico-acrid poisons, as *Lobelia inflata*, *Tupa Feuillæi*, &c.

Lobelia inflata, Indian Tobacco.—This species is a native of North America. The flowering herb and seeds have been extensively employed, especially in America, for their sedative, antispasmodic, emetic, and expectorant effects. Lobelia resembles tobacco in its action. Several fatal cases of poisoning have occurred in North America, and in this country, from its empirical use. The seeds may be distinguished under the microscope, by their peculiarly reticulated character. The root of *L. syphilitica* possesses emetic, purgative, and diuretic properties, and as its specific name implies, it has been reputed to be efficacious in syphilis. *L. urens* has blistering qualities.

L. decurrens is used in Peru as an emetic and purgative, and its use has been suggested in this country, as a substitute for Ipecacuanha.

Natural Order 132. GOODENIACEÆ. — The Goodenia Order. — Herbs or rarely shrubs, not milky. *Leaves* exstipulate. *Flowers* never collected into heads. *Calyx* generally superior, with from 3—5 divisions, occasionally inferior. *Corolla* irregular, 5-parted; *æstivation* induplicate. *Stamens* 5; *filaments* distinct; *anthers* distinct or united. *Ovary* 1, 2, or rarely 4-celled; *placenta* free central; *style* 1 (*fig.* 630, *t*); *stigma* indusiate (*fig.* 630, *i*). *Fruit* capsular, drupaceous, or nut-like. *Seeds* with fleshy albumen.

Distribution, &c. — They are principally natives of Australia, and the islands of the Southern Ocean; rarely of India, Africa, and South America. *Examples:* — Scævola, Selliera, Goodenia, Leschenaultia. There are 14 genera, and about 150 species.

Properties and Uses.—Unimportant.

Scævola Taccada has a soft and spongy pith, which is used by the Malays to make artificial flowers, &c. Its young leaves are also eaten as a pot-herb. Other species of *Scævola* are reputed to be emollient.

Natural Order 133. STYLIDIACEÆ.—The Stylewort Order.—Herbs or under-shrubs, not milky. *Leaves* exstipulate. *Calyx* superior, with 2 to 6 divisions, persistent. *Corolla* with from 5 to 6 divisions; *æstivation* imbricate. *Stamens* 2, gynandrous. *Ovary* 2-celled, or rarely 1-celled; *style* 1; *stigma* without an indusium. *Fruit* capsular. *Seeds* albuminous.

Distribution, &c. — They are chiefly found in the swamps of Australia. *Examples:* — Stylidium, Forstera. There are 5 genera, and 121 species.

Properties and Uses.—Unknown.

Natural Order 134.—VACCINIACEÆ.—The Cranberry Order. — Shrubs or small trees. *Leaves* alternate, undivided, exstipulate. *Calyx* superior. *Corolla* 4—6-lobed; *æstivation* imbricated. *Stamens* distinct, epigynous, twice as many as the lobes of the corolla; *anthers* (*fig.* 521) appendiculate, with porous dehiscence. *Ovary* 4—10-celled; *style* and *stigma* simple. *Fruit* succulent. *Seeds* with fleshy albumen.

Distribution, &c.—Chiefly natives of the temperate regions of the globe. *Examples:*—Oxycoccus, Vaccinium, Thibaudia, Lindley enumerates 13 genera, and 200 species.

Properties and Uses. — They are chiefly remarkable for their astringent leaves and bark, and for their edible sub-acid fruits.

Oxycoccus palustris or *Vaccinium Oxycoccus.*—The fruit of this plant is the Cranberry of Britain. It is used in making tarts, &c., and for other purposes. *O. macrocarpa* yields the American Cranberry, of which large quantities are imported into this country.

Vaccinium.—The fruits of several species are edible, thus:—*V. Myrtillus* yields the Bilberry or Blaeberry; *V. uliginosum*, the Bog or Black Whortleberry; and *V. Vitis-idæa*, the Red Whortleberry or Cowberry. The fruit of *V. uliginosum* is reputed to be narcotic, and it is said to be employed for making beer, &c. heady. When exposed to fermentation, it produces a kind of wine.

2. Hypostamineæ.

Natural Order 135. Brunoniaceæ.—The Brunonia Order.—Herbaceous plants. *Leaves* entire, radical, exstipulate. *Flowers* in heads, surrounded by an involucre. *Calyx* inferior, 5-parted. *Corolla* 5-parted, withering. *Stamens* few, hypogynous; *anthers* slightly coherent. *Ovary* superior, 1-celled; *ovule* solitary, erect; *style* single; *stigma* surrounded by an indusium. *Fruit* enclosed in the hardened calyx. *Seed* erect, solitary, without albumen.

Distribution, &c. — Natives of Australia. *Example:*—Brunonia. This is the only genus, of which there are 2 species.

Properties and Uses.—Unknown.

Natural Order 136. Ericaceæ. — The Heath Order. — Shrubby plants. *Leaves* entire, evergreen, opposite or whorled, exstipulate. *Calyx* 4—5-cleft, inferior, persistent. *Corolla* hypogynous, monopetalous (*figs.* 469 and 962), 4—5-cleft; *æstivation* imbricated. *Stamens* hypogynous (*figs.* 962 and 963), as many, or twice as many as the divisions of the corolla; *anthers* 2-celled, opening by a pore (*fig.* 520, *r*), appendiculate (*figs.* 520, *a*, 962 and 963). *Ovary* many-celled, with numerous ovules, surrounded by a disk or scales; *style* 1 (*figs.* 962 and 963). *Fruit* capsular, or rarely baccate; *placenta* axile. *Seeds* numerous, small, anatropous; *embryo* in the axis of fleshy albumen.

Fig. 962.

Fig. 963.

Fig. 962. Vertical section of the flower of a species of Heath (*Erica*).——*Fig.* 963. Essential organs of the same. The stamens are seen to be hypogynous.

Division of the Order, &c.—Lindley has two sub-orders as follows:—

Sub-order 1. *Ericeæ.*—Fruit loculicidal, or rarely septicidal, or berried. Buds naked. *Examples:*—Erica, Calluna, Gaultheria, Arbutus.

Sub-order 2. *Rhododendreæ.* — Fruit capsular, septicidal. Buds scaly, resembling cones. *Examples:* — Azalea, Kalmia, Rhododendron, Ledum.

Distribution, &c. — They are very abundant at the Cape of Good Hope, and are also more or less generally diffused in Europe, North and South America, and Asia. There are 42 genera, and about 850 species.

Properties and Uses.— The plants of this order are chiefly re-

markable for astringent properties; others are narcotic, and in some cases even poisonous. This is especially the case with *Kalmia latifolia*, *Rhododendron chrysanthum*, and *Azalea pontica*. The fruits of many are edible. The species of *Erica*, *Rhododendron*, *Kalmia*, *Azalea*, *&c.* are largely cultivated in this country on account of the beauty of their flowers. The three latter genera are commonly called American Plants. Such plants are not, however, confined to America as the name would imply.

Gualtheria procumbens, Partridge Berry.—The leaves possess aromatic, astringent, and stimulant properties, which they owe to the presence of a volatile oil and tannin. The oil is known under the name of *Oil of Partridge Berry*, or *Oil of Winter Green*. An infusion of the leaves is employed in certain parts of North America, as a substitute for China tea, under the name of *Mountain* or *Salvador Tea*.

Arctostaphylos Uva-Ursi, The Bearberry.—The leaves are astringent, and are frequently employed as medicinal agents in those cases where vegetable astringents are required. They have been also used as an antidote in poisoning by Ipecacuanha. Combined with astringency they also possess mild diuretic properties.

Rhododendron.—The flowers of *R. arboreum* are eaten by the hill people of India on account of their narcotic properties. The powdered leaves of *R. campanulatum* are used as snuff in certain parts of India. The brown pulverulent substance found on the petioles of some Rhododendrons and Kalmias is also used in the United States of America as a substitute for snuff. *R. chrysanthum*, a Siberian plant, possesses very marked narcotic properties.

Azalea pontica.—Trebizond honey owes its poisonous properties to the bees feeding on the flowers of this plant. The poisonous honey mentioned by Xenophon in his account of the "Retreat of the Ten Thousand," was of a like nature.

Ledum.—An infusion of the leaves of *L. palustre* and *L. latifolium* is used in North America as a substitute for China Tea, under the name of Labrador Tea, or James' Tea. It possesses narcotic properties.

Natural Order 137. Monotropaceæ.—The Fir-Rape Order.—Parasitic plants with scaly stems. *Sepals* more or less distinct, 4—5, inferior. *Petals* 4—5, distinct or united. *Stamens* twice as many as the petals, hypogynous; *anthers* 2-celled, with longitudinal dehiscence. *Ovary* superior, 4—5-celled at base, 1-celled with 5 parietal placentas at the apex. *Fruit* capsular, with loculicidal dehiscence. *Seeds* numerous, with a loose testa; *embryo* minute, at the apex of fleshy albumen.

Distribution, &c.—They are found growing on Firs chiefly, in the cool parts of Europe, Asia, and North America. *Examples:*—Monotropa, Hypopithys. There are 6 genera, and 10 species.

Properties and Uses.—Unimportant.

Natural Order 138. Pyrolaceæ.—The Winter-Green Order.—Herbs or under-shrubs, with naked or leafy stems. *Leaves* simple, evergreen. *Sepals* 5, more or less distinct, persistent, inferior. *Corolla* hypogynous, with 4—5 petals, scarcely united at their base. *Stamens* twice as numerous as the petals, hypogynous; *anthers* 2-celled, with porous dehiscence (*fig.* 524). *Ovary* superior, 4—5-celled. *Fruit* capsular, dehiscent; *pla-*

centas axile. *Seeds* numerous, with a loose testa; *embryo* minute, at the base of fleshy albumen.

Distribution, &c.—Natives of North America, Europe, and the northern parts of Asia. *Examples:* — Chimaphila, Pyrola. There are 5 genera, and 20 species.

Properties and Uses. — The plants of this order are chiefly remarkable for tonic, astringent, and diuretic properties.

Chimaphila umbellata. Winter Green, Pipsissewa. — This herb possesses diuretic and tonic properties. The fresh leaves are acrid, and when applied to the skin act as a rubefacient.

Natural Order 139. Epacridaceæ. — The Epacris Order. — Shrubs or small trees. *Leaves* alternate, or rarely opposite, simple, with parallel or radiating veins. *Calyx* and *corolla* inferior, usually 5-parted, rarely 4-parted. *Stamens* equal in number to the divisions of the corolla, or rarely fewer, hypogynous, or adherent to the corolla; *anthers* 1-celled, without appendages, opening longitudinally. *Ovary* superior, many or 1-celled; *style* simple. *Fruit* fleshy or capsular. *Seeds* with a firm skin, albuminous.

Distribution, &c. — Natives of Australia, the Indian Archipelago, and the South Sea Islands, where they are very numerous, in the same way as the *Ericaceæ* are at the Cape of Good Hope. *Examples:* — Styphelia, Astroloma, Lissanthe, Epacris. There are 31 genera, and about 320 species.

Properties and Uses. — Of little importance except for the beauty of their flowers, on which account they are much cultivated. The fruits of many are edible, as those of *Astroloma humifusum*, the Tasmanian Cranberry; *Leucopogon Richei*, the Native Currant of Australia; *Lissanthe sapida*, &c.

3. Epipetalæ.

Natural Order 140. Ebenaceæ. — The Ebony Order. — Trees or shrubs without milky juice. *Leaves* alternate, entire, coriaceous, exstipulate. *Flowers* polygamous. *Calyx* 3—7-parted, inferior, persistent. *Corolla* 3—7-parted. *Stamens*, equal in number to the lobes of the corolla, or twice, or four times as many, attached to the corolla, or hypogynous; *anthers* 2-celled, introrse, opening longitudinally. *Ovary* 3—12-celled, each cell with 1 or 2 ovules suspended from the apex; *style* usually having as many divisions as there are cells to the ovary. *Fruit* fleshy. *Seeds* large, albuminous.

Distribution, &c.— They are mostly natives of tropical India, but a few occur in colder regions. *Examples:* — Royena, Diospyros. There are 12 genera, and about 160 species.

Properties and Uses.—Many of the trees of this order are remarkable for the hardness of their wood, which is known under

the names of Ebony and Ironwood. Many species have edible fruits, and some have astringent barks.

Diospyros.—Many species of this genus have hard and dark coloured heart-woods, which form the different kinds of Ebony ; thus, from *D. Ebenus* is obtained Mauritius Ebony ; *D. Melanoxylon*, a native of the Coromandel Coast, what is commonly known as Black Ebony ; from *D. Ebenaster*, the Bastard Ebony of Ceylon. Coromandel or Calamander Wood, a beautifully variegated furniture wood, is also procured from Ceylon, and is obtained from *D. hirsuta*. Other species also yield valuable timber. The fruit of *D. Kaki* is eaten in China and Japan. It is known in Japan under the name of the Keg-fig. The fruit of *D. virginiana*, the Persimmon or Date Plum, is sweet and edible when ripe, especially after a frost; but it is very austere in an unripe state, hence it is frequently employed in that condition in the United States where it is indigenous, as an astringent. The bark has been also used as a febrifuge and astringent.

Natural Order 141. AQUIFOLIACEÆ. — The Holly Order.— Evergreen trees or shrubs. *Leaves* (*fig.* 302) coriaceous, simple, exstipulate. *Flowers* small, axillary, sometimes unisexual. *Sepals* distinct, 4—6. *Corolla* 4—6-parted, imbricated. *Stamens* equal in number to the divisions of the corolla, and alternate with its segments; *anthers* 2-celled, adnate, opening longitudinally. *Ovary* 2—6, or more celled, with one pendulous ovule in each cell; *placentas* axile. *Fruit* fleshy, indehiscent. *Seeds* suspended; *embryo* small, at the base of a large quantity of fleshy albumen.

Distribution, &c.—They are widely. although sparingly scattered over the globe. Only one species, the Common Holly, is found in Europe. *Examples:* — Ilex, Prinos. There are 11 genera, and 110 species.

Properties and Uses.—Bitter, tonic, and astringent properties are those chiefly found in the plants of this order. Some are emetic and purgative, while others are largely used as substitutes for China Tea.

Ilex.—The leaves and bark of *I. Aquifolium*, the Common Holly, have been employed in intermittent fevers. The berries are purgative and emetic. Bird-lime is prepared from the bark, and its white wood is used by cabinet makers for inlaying. A decoction of the leaves of *I. vomitoria* constitutes the Black drink of the Creek Indians. The leaves and young twigs of *I. paraguayensis*, the Brazilian or Paraguay Holly, are extensively employed in South America as Tea, under the name of Maté or Paraguay Tea. It is remarkable that Maté contains Theine, the vegetable principle already noticed as existing in Chinese Tea. (See *Thea*, page 476). Like Chinese Tea it also contains a vegetable oil, tannin, and gluten. It has somewhat similar properties to Chinese Tea, but is more exciting, and when taken to excess produces a kind of intoxication. In Brazil a kind of Maté, called Gongonha, is prepared from *I. gongonha* and *I. theezans*. Maté tea is generally used in Brazil, Paraguay, Peru, Uruguay, Chili, &c. Johnston estimates the consumption of Maté at 20 millions of pounds annually. From the great astringency of the fresh leaves of *I. paraguayensis*, *I. gongonha*, &c., they are used by the dyers in Brazil.

Prinos glaber.—The leaves of this plant, which is a native of North America, are used as a substitute for China Tea. This is known under the name of Appalachian Tea. (See page 569, *Viburnum.*) The bark of *P. verticillatus*, called *Black Alder Bark* or *Winter Berry*, is employed in the United States in the form of a decoction, as a tonic and astringent.

Natural Order 142. SAPOTACEÆ.—The Sapota or Sapodilla

Order.—Trees or shrubs, often having a milky juice. *Leaves* alternate, simple, entire, coriaceous, exstipulate. *Flowers* hermaphrodite. *Calyx* usually with 5, or sometimes with 4—8 divisions, persistent. *Corolla* with as many divisions as the calyx, or twice, or thrice, as many. *Stamens* definite, in a single row, half of them sterile and alternating with the fertile ones, the latter being opposite to the segments of the corolla; *anthers* commonly extrorse. *Ovary* 4—12-celled, with a solitary anatropous ovule in each cell; *style* 1. *Fruit* fleshy. *Seeds* large, with a shining bony testa; *embryo* large, usually in albumen, and with a short radicle.

Distribution, &c.—Natives chiefly of the tropical parts of Asia, Africa, and America. *Examples:*—Chrysophyllum, Achras, Isonandra, Bassia. There are 21 genera, and 212 species.

Properties and Uses.—Many species yield edible fruits. The seeds of several contain a fatty oil. Some have bitter astringent febrifugal barks, and the milky juices of others yield a substance analogous in its general characters to caoutchouc.

Chrysophyllum.—The fruit of *C. Cainito* is known under the name of the Star-apple. It is much esteemed. Other species of *Chrysophyllum* also yield edible fruits. *C. Buranheim* yields an astringent bark called *Monesia bark*, which has been much employed in France and Germany. It contains an acrid principle called *monesine*, which is analogous to *saponine*. Monesine has been also employed as a medicinal agent.

Lucuma.—Several species yield edible fruits. The kernels of *L. mammosa* are said to yield an abundance of hydrocyanic acid.

Achras.—Several species of this genus yield dessert fruits. That of *A. Sapota* is the Sapodilla Plum; that of *A. mammosa*, the Marmalade. *Achras Sapota* has also a febrifugal bark, and diuretic and aperient seeds. Its wood is called Bully-tree Wood or Black Bully. This has a greenish colour, and is very hard. It is imported, and used for ship-building, &c. The bark of several other species has been also employed as a substitute for Cinchona. *Achras* or *Sapota Mulleri*, a native of Guiana and Central America, yields a kind of Gutta Percha, called *Balatas*. Some has been recently brought to this country for investigation of its merits. It is said to be of good quality.

Isonandra Gutta, the Gutta Percha or Taban-tree.—This is a native of Singapore, Borneo, and other Malay Islands. From this and other species of *Isonandra*, the valuable substance called Gutta Percha is obtained. Dr. Seemann states, that the *I. Gutta* has become almost extinct.

Bassia.—The ripe kernels of *B. latifolia* and those of *B. longifolia*, the Elloopa-tree, yield fatty oils which are much employed in India, for lamps, for culinary purposes, in soap-making, and externally in cutaneous affections. The flowers and fruits serve as food to man and other animals; and the flowers by distillation yield an alcoholic spirit, which is in much repute in some districts. The flowers of *B. longifolia*, under the name of *Elloopa* have been recently imported into London. The wood of *B. longifolia* and others is hard and durable, and the bark and leaves are used in medicine. The Shea or Galam butter of African travellers is said to be yielded by another species of *Bassia*.

Mimusops.—The fruit of several species is employed as a dessert; that of *M. Elengi* is the Surinam Medlar. The fruit of *M. Kaki* is much eaten in India. It has an astringent bark. The seeds of some species yield useful oils.

Natural Order 143. STYRACACEÆ.—The Storax Order.—Trees or shrubs. *Leaves* simple, alternate, exstipulate. *Flowers* axillary. *Calyx* inferior, or superior, 4—5-parted, or almost entire, persistent. *Corolla* of 5—10 petals, either

united at the base, or distinct; *æstivation* imbricate, or somewhat valvate. *Stamens* equal in number to the petals, or twice, or thrice, as many, more or less coherent at the base; *anthers* 2-celled, roundish or linear. *Ovary* superior or inferior; *style* simple. *Fruit* drupaceous, always more or less fleshy. *Seeds* 1 usually in each cell, sometimes more; *embryo* in the midst of abundant fleshy albumen, with a long radicle. Miers has divided the *Styracaceæ* into two orders, called *Symplocaceæ* and *Styraceæ*, the former of which is essentially distinguished by its inferior ovary, imbricated æstivation of the corolla, and roundish anthers.

Distribution, &c.—The plants of this order are sparingly distributed in warm and tropical regions; a few only are found in cold climates. *Examples*:—Symplocos, Styrax, Halesia. Miers enumerates 12 genera, and about 120 species.

Properties and Uses.—The plants of this order are principally remarkable for yielding stimulant balsamic resins. Some yield dyeing agents, but these are of little importance.

Symplocos. — The leaves of *S. Alstonia* or *Alstonia theaformis*, are slightly astringent. They have been employed as Tea in New Granada, under the name of Santa-Fé Tea. The leaves of *S. tinctoria* (Sweet-leaf, or Horse-Sugar), a native of North America, have a sweet taste, and are eaten by cattle. They are also used in dyeing yellow. This plant has a bitter and aromatic root.

Styrax. — The plants of this genus commonly yield stimulant balsamic resins. *S. Benzoin*, the Benjamin tree, yields the well-known concrete Balsamic exudation which is commonly called Gum Benjamin. It is obtained from incisions in the bark. Two kinds are distinguished in commerce under the names of *Siam*, and *Sumatra benzoin*. The former is most esteemed in England. It is used in medicine as a stimulant expectorant. It is, however, chiefly employed for the preparation of *benzoic acid;* and on account of its agreeable odour when heated, for fumigations in the ceremonies of the Roman Catholic and Greek churches, and also as an ingredient in Aromatic or Fumigating Pastilles, and in Court or Black Sticking Plaster. In Brazil other species of *Styrax* yield similar balsamic exudations. *S. officinale* a native of Greece, the Levant and Asia Minor, has been supposed by many to be the source of our commercial *Liquid Storax*, but Mr. Daniel Hanbury has proved that while it was the source of the original and classical Storax, this has in modern times wholly disappeared from commerce, and that our *Liquid Storax* is the produce of *Liquidambar orientale* of Miller (See *Liquidambar*). Storax has similar medicinal properties to Benzoin.

Natural Order 144. APOCYNACEÆ.—The Dog-bane Order.—Trees or shrubs, usually milky. *Leaves* entire, usually opposite, occasionally whorled or scattered, exstipulate. *Calyx* 5-parted (*fig.* 965), persistent. *Corolla* (*figs.* 964 and 965) 5-lobed; *æstivation* contorted. *Stamens* (*fig.* 965) 5, alternate with the lobes of the corolla; *filaments* distinct; *anthers* united to the stigma (*fig.* 964), 2-celled (*fig.* 515); *pollen* granular. *Ovary* composed of 2 carpels (*figs.* 964 and 965), which are generally merely in contact, or rarely united so as to form a 2-celled ovary; *styles* 2 or 1 (*fig.* 584); *stigma* 1, expanded at the base and apex, and contracted in the middle, so as to resemble in shape an hour-glass, or dumb-bell (*fig.* 584, *s*); *ovules* numerous.

Fruit consisting of 1 or 2 follicles, or a capsule, drupe, or berry. *Seeds* usually with albumen, rarely exalbuminous.

Fig. 964.

Fig. 965.

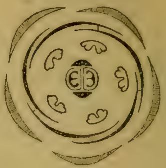


Fig. 964. Vertical section of the flower of Periwinkle (*Vinca*).——*Fig.* 965. Diagram of the flower.

Distribution, &c.—Natives principally of tropical regions, a few only occurring in northern regions. *Vinca* is the only British genus. *Examples:*—Allamanda, Vahea, Cerbera, Tanghinia, Urceola, Vinca, Balfouria, Nerium, Apocynum. There are 108 genera, and 570 species.

Properties and Uses.—The plants of this order are generally to be suspected, as many of them are intensely poisonous, although the fruit of some is eatable. Some are drastic purgatives, and in some the bark is tonic and febrifugal. They have generally large showy flowers, and hence form some of the most beautiful of our stove plants; as, *Allamanda*, *Dipladenia*, *Plumiera*, *Nerium*, *&c.* Caoutchouc is obtained from the milky juice of several species.

Hancornia speciosa bears a delicious fruit, which is much esteemed by the Brazilians.

Carissa Carandas also bears an edible fruit, which is eaten in the East Indies where it is used as a substitute for Red Currant jelly. The fruits of *C. edulis* and *tomentosa* are also eaten in Abyssinia.

Vahea gummifera, a native of Madagascar, yields a kind of caoutchouc, but that used in this country is chiefly obtained from *Siphonia elastica*.

Alyxia stellata has an aromatic bark, which is analogous in its properties to that of Canella and Winter's Bark.

Tanghinia venenifera, the Madagascar Poison-nut. — The seeds of this plant are amongst the most deadly of poisons. It is said that one not larger than an almond will destroy twenty persons. It was formerly used as an ordeal in Madagascar.

Nerium Oleander, the Oleander or Rose-bay. The stem, leaves, and flowers are very poisonous.

Urceola elastica is one of the principal plants of the order yielding caoutchouc. It is a native of the East Indies.

Tabernæmontana utilis, the Hya-Hya, or Cow-tree of Demerara, has a milky nutritious juice.

Roupellia grata, a native of Sierra Leone, yields an edible fruit called Cream fruit.

Aspidosperma excelsum, a native of Guiana, is remarkable for its fluted trunk. It is employed for making paddles.

Alstonia scholaris, has a bitter tonic, and astringent wood.

Wrightia antidysenterica. — The bark is febrifugal and astringent. It is called Conessi bark. The seeds have similar properties. Both the bark and seeds are much used in India. From *W. tinctoria* a blue dye resembling Indigo is obtained. The wood of *W. coccinea* and *W. mollissima* are also employed in India for palanqueens, and by turners.

Apocynum. — The roots of *A. cannabinum* and *A. androsæmifolium* are emetic, and slightly purgative.

Natural Order. 145. LOGANIACEÆ. — The Spigelia or Strychnos Order. — Shrubs, herbs, or trees. *Leaves* opposite, entire, with stipules; the latter, however, sometimes exist only in the form of a raised line or ridge. *Calyx* (*fig.* 464) 4—5-parted. *Corolla* (*fig.* 464) regular, 4—5, or 10-cleft; *æstivation* valvate or convolute. *Stamens* sometimes anisomerous; *anthers* 2-celled; *pollen* 3-lobed. *Ovary* 2, 3, or 4-celled; *style* simple below, and with as many divisions above as there are cells to the ovary; *stigma* simple. *Fruit* capsular, or drupaceo-baccate; *placentas* axile, ultimately detached. *Seeds* usually peltate, sometimes winged, with fleshy or cartilaginous albumen. This order is by no means well defined.

Distribution, &c.—Almost all natives of tropical regions. *Examples:* — Spigelia, Logania, Buddleia, Strychnos. There are 25 genera, and about 200 species.

Properties and Uses. — The plants of this order are almost universally poisonous, acting on the nervous system and producing frightful convulsions. Some have been used in medicine in torpid or paralytic conditions of the muscular system, and as tonics and anthelmintics, but they require much caution in their employment, and can generally be only given in very small doses.

Spigelia Marylandica, Carolina Pink, Wormseed, Perennial Wormgrass. The root and leaves are much employed in North America as anthelmintics. In larger doses they operate as irritant cathartics, and in poisonous doses as narcotics. They are but little used in this country. *S. Anthelmia*, Demerara Pink Root, is employed for similar purposes in Guiana and the West Indies.

Ignatia amara. — This plant has been supposed to yield the seeds known as St. Ignatius's beans, but according to Bentham, this genus has been improperly formed, and he believes that these seeds are the produce of a species of *Strychnos*, perhaps of *S. multiflora*. They come to us from the Philippine Islands. They are intensely bitter, and contain the alkaloid Strychnia in even larger proportions than Nux Vomica seeds. Their effects are similar to them. (See *Nux Vomica* below.)

Strychnos. — This genus contains some of the most poisonous plants that are known. *S. Nux-vomica*, the Koochla tree, produces Nux Vomica seeds, so well known for their powerfully poisonous effects. They owe their virulent properties to the presence of the alkaloids *strychnia* and *brucia*; $\frac{3}{4}$ of a grain of strychnia has been known to produce death. But the seeds and the alkaloid strychnia have been employed as stimulants of the nervous system in paralysis. Nux Vomica seeds are imported into this country from Coromandel, Ceylon, &c. In consequence of the enormous quantities which have been of late years brought to this country, it was thought by some that they were employed in the manufacture of *bitter ale* on account of their intense bitter-

ness, but although this has been satisfactorily disproved, it is still unknown for what purposes they are so largely required, and with such a powerful poison it would be very satisfactory to have this circumstance explained. A large quantity of both nux vomica seeds and strychnia are, however, employed by gamekeepers, &c. to destroy vermin, &c. The bark of *S. Nux-Vomica* is also powerfully poisonous owing to the presence of *brucia.* As already noticed, it was formerly confounded with *cusparia* or *angustura bark* (see p. 502): hence it is also known as *false angustura bark.* This bark is also frequently sold in Calcutta under the name of *Rohun*, from which circumstance it has been substituted for the febrifuge bark of *Soymida febrifuga*, the Rohuna tree (see p. 491). An aqueous extract of the bark of *Strychnos Tieuté* is the Java poison, called Upas Tieuté. It owes its poisonous properties to strychnia. The juice of *S. toxifera*, is the basis of the celebrated *Wourali*, *Urari*, or *Ourari* poison of Guiana. From *S. cogens*, a similar arrow poison is also prepared by some of the Indian tribes in South America. Wourali has been recently much employed in tetanus, but with very uncertain effects. The wood of *S. colubrina* and *S. ligustrina* is employed in certain parts of Asia as an antidote to the bites of poisonous snakes, hence it is known under the name of *Lignum Colubrinum* or Snake-wood. Several other kinds of wood are, however, known in Asia, under the same name. *Lignum colubrinum* has been also employed as a cure for intermittent fevers, and for other purposes. It contains strychnia, and therefore requires much caution in its employment. The bark of *S. Pseudoquina* is extensively employed in the Brazils as a substitute for Cinchona Bark. It contains neither strychnia nor brucia, and is devoid of poisonous properties. It is frequently erroneously called *copalchi bark* (See *Croton* for the origin of this bark). The dried ripe seeds of *S. potatorum* are employed by the Hindoos to clear muddy water, hence the name of *Clearing-nuts* which is commonly applied to them. Their efficacy is due to the presence of albumen and casein, which act as fining agents in a similar manner to analogous agents employed for beer and wine. The pulp of the fruit is eatable, as is also that of *S. Pseudoquina;* and according to Roxburgh, that of *S. Nux Vomica;* this is greedily eaten by birds.

Natural Orders 146, and 147. DIAPENSIACEÆ, and STILBACEÆ. —These are two small orders of shrubby plants which are placed by Lindley in his Gentianal alliance, and regarded by him as nearly allied to *Loganiaceæ.* The *Diapensiaceæ*, (of which there are but 2 genera, and 2 species, the uses of which are unknown), are natives of North America, and Northern Europe; and the *Stilbaceæ*, (of which there are 3 genera, and 7 species, without any known uses), are natives of the Cape of Good Hope.

Natural Order 148. GENTIANACEÆ.—The Gentian Order. —General Character.—Herbs, or rarely shrubs, usually smooth. *Leaves* (*fig.* 412) usually simple, entire, opposite, sessile, and strongly ribbed; rarely alternate, or stalked, or compound, always exstipulate. *Flowers* (*fig.* 412) almost always regular, variously coloured, axillary or terminal. *Calyx* inferior, persistent, usually with 5 divisions, occasionally 4, 6, 8, or 10. *Corolla* persistent, its divisions corresponding in number to those of the calyx; *æstivation* imbricate, twisted, or induplicate. *Stamens* as many as the segments of the corolla, and alternate with them. *Ovary* 1-celled, or rarely partially 2-celled from the projection inwards of the placentas, with numerous ovules; *placentas* 2, parietal (*fig.* 664), anterior and posterior to the axis, and frequently turned inwards; *style* 1; *stigmas* 2, right and left of the axis. *Fruit* capsular (*fig.* 664),

2-valved, with septicidal dehiscence; or a berry. *Seeds* numerous (*fig.* 664), small; *embryo* minute, in the axis of fleshy albumen.

Diagnosis. — Usually smooth herbs. Leaves without stipules. Flowers nearly always regular. Calyx and corolla persistent, with an equal number of lobes. Stamens alternate to the lobes of the corolla, and equal in number to them. Ovary 1-celled, with 2 parietal placentas placed anterior and posterior, sometimes meeting in the centre and forming a 2-celled ovary; style 1; stigmas 2. Seeds numerous, with a minute embryo, in the axis of fleshy albumen.

Division of the Order, &c. — The order has been divided into two sections or sub-orders, the characters of which are taken from the æstivation of the corolla: —

Sub-order 1. *Gentianeæ.* — Corolla imbricate-twisted. *Examples:* — Gentiana, Agathotes, Erythræa, Chlora.

Sub-order 2. *Menyantheæ.*—Corolla plaited, or induplicate. *Examples*: — Menyanthes, Villarsia.

Distribution, &c. — They are found in nearly all parts of the world, inhabiting both the coldest and hottest regions. There are 64 genera, and about 450 species.

Properties and Uses. — A bitter principle almost universally pervades the plants of this order; hence many of them are tonic, stomachic, and febrifugal.

Gentiana lutea.—This plant is a native of the mountains of central and southern Europe. Its root is our officinal Gentian, so well known for its bitter tonic properties. The roots of other species of Gentian are frequently mixed with it, as those of *G. purpurea*, *punctata*, and *pannonica*, the admixture is, however, of little consequence, as these possess similar properties. From Gentian root, the Swiss and Tyrolese prepare a spirit which is much prized by them as a stomachic. Other Gentians have similar properties.

Ophelia (*Agathotes*) *Chirata*, the Chiretta or Chirayta.—The dried plant and root possess great bitterness. Chiretta is used by the natives of India as Gentian is employed in Europe. It is also in use as a tonic &c. in this country, &c.

Frasera carolinensis or *Walteri.*—The root is officinal in the Pharmacopœia of the United States. It is known as American Columba. It has much less bitterness than Gentian root; and though similar in properties, it is less powerful. It has been sold for Columba in France, and hence termed *false Columba.*

Erythræa Centaurium, Common Centaury, is an indigenous plant possessing similar properties to Gentian.

Sabbatia angularis, American Centaury. — The herb and root are employed in the United States for their tonic and febrifugal properties.

Menyanthes trifoliata, Buck-bean, Bog-bean, or Marsh Trefoil. — The leaves and rhizome are tonic and astringent, and in large doses cathartic and emetic. The plant has been employed in some parts of Germany as a substitute for hops.

Natural Order 149. Asclepiadaceæ. — The Asclepias or Milkweed Order (*figs.* 966—968.) Shrubs or herbs, commonly lactescent and frequently of a twining habit. *Leaves* entire, exstipulate. *Flowers* regular (*figs.* 966 and 967). *Calyx* and *corolla* 5-partite (*figs.* 966 and 967); *æstivation* of the latter imbricated, or rarely valvate; the calyx persistent (*fig.* 551, *a*), the corolla

deciduous. *Stamens* 5 (*fig.* 966), alternate with the lobes of the corolla; *filaments* usually combined so as to form a tube round the pistil (*fig.* 967), sometimes distinct; "*pollen* when the anther dehisces, cohering in masses (*fig.* 551, *p*), and sticking to 5 processes of the stigma (*fig.* 551, *p*) by twos, or fours, or singly." *Ovary* (*fig.* 966) formed of 2 carpels, which are more or less adherent below, but distinct above; *styles* 2; *stigmas* united and expanded into a fleshy 5-cornered head, the pollen masses adhering to gelatinous processes arising from its angles (*figs.* 551 and 967). *Fruit* consisting of 2 follicles, or 1 by abortion.

Fig. 966.

Fig. 967.

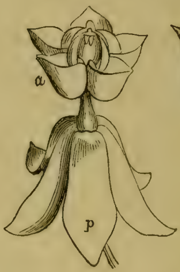


Fig. 968.

Fig. 966. Diagram of the flower of *Asclepias nivea*.——*Fig.* 967. Flower of a species of *Asclepias*, with the united stamens around the pistil. *p*. Corolla. *a*. Appendages of the stamens.——*Fig.* 968. One of the stamens of the above removed. *f*. Filament. *a*. Anther. *p*. Horn-like staminal appendage.

Seeds numerous, generally comose (*fig.* 732), with thin albumen. This order is at once distinguished amongst the Epipetalæ, by its curiously formed stigma, and adhering pollen masses.

Distribution, &c. — They are chiefly tropical plants, abounding in southern Africa, India, and equinoctial America. *Examples:* — Hemidesmus, Secamone, Solenostemma, Calotropis, Asclepias, Matelia, Hoya, Stapelia. There are 157 genera, and about 930 species.

Properties and Uses. — The plants of this order are chiefly remarkable for their bitter acrid juice, which renders them stimulating, emetic, purgative, and diaphoretic. The milky juice of many species contains caoutchouc. Some are edible, as the roots of *Gomphocarpus pedunculatus*, and the tubers of *Ceropegia Vignaldiana, &c.*

Hemidesmus indicus.—The roots are known under the names of *Indian, scented*, or *country sarsaparilla*, and have been also imported into this country under the name of *Smilax aspera*, from an erroneous idea of their being obtained from that plant. They are supposed by some to be a cheap and efficient substitute for true sarsaparilla, which they resemble in their properties.

Solenostemma (*Cynanchum*) *Argel.*—The leaves have been much employed to adulterate Alexandrian Senna. (See *Cassia*, p. 529.)

Calotropis gigantea or *procera*, yields *Mudar bark*, which has been much employed in India in cutaneous affections. It has been also used as a substitute for ipecacuanha. It contains a principle called *mudarine*. According to Royle, *Ak* or *Mudar* fibres are obtained from this bark. The bark of the root of *C. Hamiltonii* possesses similar properties, and is said to yield *Yercum* fibres.

Cynanchum monspeliacum.—The expressed juice of this plant mixed with other purgative substances constitutes *French* or *Montpellier Scammony*. *C. ovalifolium* yields excellent caoutchouc at Penang.

Asclepias Curassavica.—The root is employed in some of the West Indian islands as an emetic, hence it is termed Bastard Ipecacuanha. From the stems of *A. tenacissima*, the *Jetee* or *Tongoose* fibres are obtained. The root of *A. tuberosa*, the Butterfly-weed or Pleurisy-root, is employed in the United States as a diaphoretic and expectorant. *A. incarnata*, Swamp Silk-weed, is used in North America as an anthelmintic, and in asthma and rheumatism.

Marsdenia tinctoria, a native of Silhet, produces a kind of indigo. *M. tenacissima* has very tenacious fibres which are used for bow-strings by the mountaineers of Rajmahl.

Gymnema lactifera is the Cow-plant of Ceylon. It yields a nutritious milk which is used as food.

Natural Order 150. Cordiaceæ. — The Cordia or Sebesten Order. — *Trees* with alternate scabrous leaves, exstipulate. *Calyx* and *corolla* 5-merous; *æstivation* of the corolla imbricated. *Stamens* 5, alternate with the segments of the corolla; *anthers* versatile. *Ovary* 4—8-celled, with 1 pendulous ovule in each cell; *stigma* 4—8-cleft. *Fruit* drupaceous, 4—8-celled, or frequently some of the cells are abortive; *placentas* axile. *Seeds* 1 in each cell, pendulous by a long cord; *albumen* none; *cotyledons* plaited longitudinally.

Distribution, &c. — Natives almost exclusively of tropical regions. *Examples:* — Cordia, Varronia, Sebestena. There are 11 genera, and 180 species.

Properties and Uses. —The fruits of many species are edible; as those of *Cordia Myxa* and *latifolia*, called Sebestens or Sebesten plums, which are eaten by the natives &c. in India; those of *Cordia abyssinica*, Wanzey or Vanzey, which are esteemed by the Abyssinians; and the succulent fruits of *Varronia rotundifolia* which are used to fatten cattle and poultry. The bark of *C. Myxa* is reputed to be a mild tonic and astringent.

Natural Order 151. Convolvulaceæ. — The Convolvulus or Bindweed Order (*figs.* 969—971). — Herbs or shrubs, generally twining (*fig.* 205) or trailing, and milky. *Leaves* (*fig.* 205) alternate, exstipulate. *Calyx* (*figs.* 969 and 970) with 5 deep divisions, much imbricated, persistent. *Corolla* (*figs* 969 and 970) 5-partite or 5-plaited, regular, deciduous, without scales in its tube; *æstivation* plaited. *Stamens* 5, alternate with the lobes of the corolla (*fig.* 970). *Ovary* (*fig.* 970) 2, 3, or 4-celled, or the carpels are more or less distinct; *ovules* 1—2 in each cell or carpel, erect. *Fruit* capsular, 1—4-celled, with septifragal dehiscence. *Embryo* (*fig.* 971) large, curved or coiled in a small quantity of mucilaginous albumen, with foliaceous crumpled cotyledons.

Fig. 969.

Fig. 970.

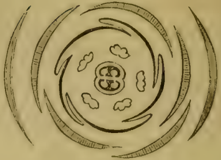


Fig. 971.

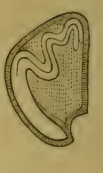


Fig. 969. Flower of Great Bindweed (*Calystegia sepium*).——*Fig.* 970. Diagram of the flower, showing two bracts on the outside of the calyx, &c.——*Fig.* 971. Vertical section of the seed.

Distribution, &c. — They are chiefly found in the plains and valleys of hot and tropical regions. A few occur in temperate climates, but they are altogether absent in the coldest latitudes. *Examples :* — Calystegia, Convolvulus, Exogonium, Ipomœa, Batatas, Dichondra. There are 47 genera, and about 665 species.

Properties and Uses. — They are chiefly remarkable for the presence of an acrid milky purgative juice in their roots, hence the order includes some important medicinal plants. The purgative property of the juice is due to a peculiar resin. In the roots of other species this resin is either absent or in but small quantity, and starch or sugar predominates, which renders them edible. The seeds of some species are also purgative.

Convolvulus, Bindweed.—From the incised fresh root of *C. Scammonia*, the valuable purgative gum-resin called Scammony is obtained. This plant is a native of Asia Minor, Syria, the Levant, and Greece. The greater part of the Scammony of English commerce is imported from Smyrna. The roots of many other species also possess in a certain degree purgative properties; as those of our native species, *Convolvulus* or *Calystegia sepium*, *arvensis*, and *Soldanella*, *&c.* It is said that *Convolvulus dissectus* contains hydrocyanic acid, and is one of the plants which is used for flavouring *Noyau*.

Rhodoriza.—From the species of this genus the volatile oil called Oil of Rhodium is said to be obtained. The powdered wood is used for snuff, and for fumigation.

Exogonium purga.—This plant is a native of Mexico, near Chicanquiaco. Its tubercular roots constitute the true Jalap of the Materia Medica, so well known as a purgative.

Ipomœa.—The roots of *T. Orizabensis* are sometimes found intermixed with true jalap. This spurious jalap is known in Mexico as *male jalap*, and in English commerce as *woody jalap* or *jalap wood*, and on the Continent as *light* or *fusiform jalap*. It possesses similar, although less powerful properties than those of true jalap. The roots of *I. Turpethum*, Turpeth, were formerly much used as a purgative. The large roots of *I. macrorhiza* contain much farinaceous matter, and are eaten by the inhabitants of Georgia and Carolina.

Batatas edulis.—The root of this plant constitutes the Sweet-Potato, which is largely used as food in many tropical countries.

Pharbitis Nil.—The seeds are known in India under the names of *mirchai*, and *kala dana*. They possess similar medicinal properties to those of jalap.

Natural Order 152. CUSCUTACEÆ.—The Dodder Order (*figs.* 972, 973).—*Diagnosis.*—This is a small order which is generally regarded as a sub-division of Convolvulaceæ. The plants

Fig. 972.

Fig. 973.

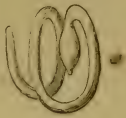


Fig. 992. Corolla of Dodder (*Cuscuta*) laid open, to show the scales, and stamens.——*Fig.* 973. Spiral embryo of a *Cuscuta*.

composing it are distinguished from that order by their parasitic habit (*fig.* 238); by the absence of leaves (*fig.* 238); by the tube of their corolla being furnished with scales (*fig.* 972), which alternate with its segments; and by having a filiform coiled embryo (*fig.* 973), with almost obsolete cotyledons.

Distribution, &c.—Chiefly natives of temperate climates. There are 4 genera, and 50 species.

Properties and Uses.—They are said to be purgative in their action. They are often very destructive to Flax, Clover, and other crops.

Natural Order 153. POLEMONIACEÆ.—The Phlox Order.—Herbs. *Leaves* opposite or alternate. *Calyx* 5-parted, persistent, generally regular. *Corolla* 5-lobed, with contorted, or occasionally imbricated æstivation. *Stamens* 5, alternate with the segments of the corolla; *pollen* usually of a blue colour. *Ovary* 3-celled; *style* 1; *stigma* trifid. *Fruit* capsular, 3-celled, 3-valved; *placentas* axile. *Seeds* few or many; *embryo* straight in the axis of copious horny albumen; *cotyledons* elliptical, foliaceous.

Distribution, &c.—They abound most in the temperate parts of North and South America. They are far less abundant in Europe and Asia, and altogether unknown in tropical countries. *Examples*:—Phlox, Collomia, Polemonium, Cobæa. There are 17 genera, and 104 species.

Properties and Uses.—Of no importance except for the prettiness of their flowers. The seeds of *Collomia* and some other plants of this order have their testa covered with hair-like

cell containing a spiral fibre; these fibres in *Collomia* expand in coils when the seeds are moistened. (See p. 337.)

Natural Order 154. SOLANACEÆ. — The Solanum or Potato Order (*figs.* 974—976).— This order is defined according to the

Fig. 974.

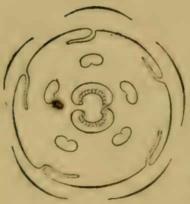


Fig. 975.

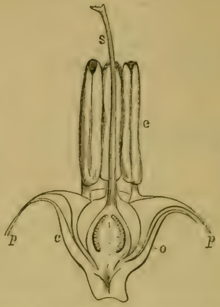


Fig. 976.

Fig. 974. Diagram of the flower of the Potato (*Solanum tuberosum*).——*Fig.* 975. Vertical section of the flower. *c.* Calyx. *p, p.* Corolla. *o.* Ovary. *e.* Stamens. *s.* Style and stigma.——*Fig.* 976. Vertical section of the seed of *Solanum Dulcamara.* *te.* Testa. *ch.* Chalaza. *alb.* Albumen.

views of Miers, as follows:—Herbs or shrubs. *Leaves* alternate, often geminate. *Inflorescence* axillary, or more frequently extra-axillary (*fig.* 331). *Flowers* isomerous (*fig.* 974). *Calyx* (*fig.* 974) with 5, or rarely 4 divisions. *Corolla* (*fig.* 974) regular, or nearly so, 5, or rarely 4-partite; *æstivation* valvate or induplicate-valvate. *Stamens* equal in number to the lobes of the corolla with which they are alternate (*fig.* 974), the fifth stamen very rarely sterile; *anthers* introrse, with longitudinal or porous dehiscence (*fig.* 527). *Ovary* (*figs.* 974 and 975) usually 2-celled, rarely 3 to 5-celled; *style* (*fig.* 975) simple; *stigma* clavate or 2-lobed. *Fruit* capsular or baccate, 2 or more celled. *Seeds* numerous, albuminous, with the embryo straight, or curved in a more or less annular or spiral form (*fig.* 976).

Division of the Order, &c. — The order may be divided as follows :—

Sub-order 1. *Rectembryeæ.*—Embryo short and straight. *Examples :* — Metternichia, Cestrum, Fabiana.

Sub-order 2. *Curvembryeæ.*—Embryo slender, terete, and curved in a more or less annular or spiral form. *Examples :* — Physalis, Capsicum, Solanum, Lycopersicon.

Distribution, &c. — They are scattered over various parts of the globe except the polar circles, but are most abundant in

tropical regions. *Examples*:— Physalis, Cestrum, Habrothamnus, Capsicum, Solanum. Miers enumerates 42 genera as belonging to this order.

Properties and Uses.— The plants of this order frequently possess narcotic properties, but not by any means to the same extent as those of the Atropaceæ of Miers. Some are pungent and stimulant owing to the presence of an acrid resin. Others contain a bitter tonic principle, and a few have edible fruits, or tubers. It has been stated that the juice of the Solanaceæ does not produce dilatation of the pupil as is the case with many plants of the order Atropaceæ.

Physalis peruviana has an edible fruit which is called the Peruvian Winter Cherry. *P. alkekengi*, Winter Cherry, and some other species, are diuretic. *P. somnifera*, as its name implies, possesses narcotic properties.

Punneeria coagulans.—The dried fruit is employed in India as a carminative and stomachic, and also as a substitute for rennet in making cheese, &c.

Capsicum.—The species of this genus are remarkable for the presence of an acrid resin (*capsicine*) in their fruits, which renders them hot, pungent, and stimulating. The various species of *Capsicum* are generally supposed to be natives of South America, from whence they have become distributed over the world. There are several species and varieties of *Capsicum* in common use, one of which is officinal, namely, the *C. annuum* of Linnæus, or the *C. fastigiatum* of Blume. The fruits of this are commonly sold as *chillies*. They are sometimes two or three inches in length, whilst in other varieties they are not more than one inch. The shorter variety is the best. Cayenne Pepper is the powdered fruits of probably several species of *Capsicum* found in the West Indies and South America, but principally it is said of *C. frutescens* (Bird-pepper or Guinea-pepper), and perhaps of *C. baccatum*. Other varieties or species of *Capsicum*, are the *C. cerasiforme* (Cherry-Pepper or Round Chilli), *C. grossum* (Bell Pepper), &c.

Solanum.—The Common Patato, which is so largely used as food in temperate climates, is the tuber of *S. tuberosum*. A decoction of the stem and leaves of *S. tuberosum* has been used as an alterative in cutaneous diseases, and an extract of the herb has been also employed as a narcotic and antispasmodic. The medicinal properties of the potato plant are chiefly due to the presence of a small quantity of an alkaloid called *Solanina*, which has powerful narcotic properties. Solanina does not produce dilatation of the pupil like the alkaloids of the Atropaceæ; and hence the reason why the juice of the Solanaceæ generally differs in such respect from that of Atropaceæ. Solanina has been detected in all parts of the Potato plant, but in the tuber only traces of it are to be found, and these are entirely removed by the process of boiling and preparing potatoes for the table. Starch is largely obtained from potatoes, and used for food under the names of *English arrow-root, Bright's nutritious farina, &c.* It is also employed in the preparation of *dextrine* or *Starch-gum*, which is used in the arts, &c. as a substitute for gum, size, and paste. *Solanum Dulcamara*, Woody Nightshade or Bitter-sweet. The stem and twigs of this plant are employed as an alterative in cutaneous diseases. They also possess slight narcotic properties owing to the presence of solanina. *S nigrum*, Black Nightshade, also possesses alterative and narcotic properties. The fruit is said to be edible, but if this be the case, its use for food requires caution, as solanina has been found in it. The fruits of several species of *Solanum* are however eaten in various parts of the world, as those of *S. Melongena* and *ovigerum*, called Egg-apples; those of *S. quitoense*, named Quito Oranges; also those of *S. laciniatum* in Australia, where they are termed Kangaroo-apples; and those of *S. muricatum* and *nemorense* in Peru. *S. marginatum* has astringent properties, and is employed in Abyssinia in the process of tanning. *S. Pseudo-quina*, a Brazilian species, is much employed in that country as a tonic and febrifuge. Several species of *Solanum* are also reputed to have diuretic properties, as *S. mammosum*, *paniculatum*, *&c.* The flowers and leaves of *S. cernuum* are sudorific, and have been employed in gonorrhœa, syphilis, &c.

Lycopersicon esculentum.—This plant produces the fruits called Love-apples or Tomatoes so much employed in the preparation of sauces.

Natural Order 155. Atropaceæ. — The Deadly Nightshade Order (*figs.* 977, 978).—*Diagnosis.* — The plants included in

Fig. 977.

Fig. 978.

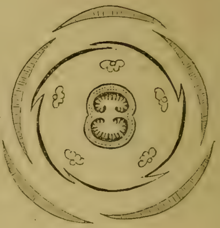


Fig. 977. Vertical section of the flower of Tobacco (*Nicotiana Tabacum*).——*Fig.* 978. Diagram of the flower of Tobacco.

this order were separated by Miers from the Solanaceæ and Scrophulariaceæ, and formed into a distinct order under the above name. In habit, character of the leaves, inflorescence, calyx, ovary, fruit, and seeds, the Atropaceæ agree essentially with the Solanaceæ; but they differ in the *æstivation* of their corollas being always more or less imbricated (*figs.* 466 and 978) instead of valvate; in the lobes of the corolla being frequently somewhat unequal; in 1 or more of the stamens, which are normally 5, being more frequently sterile; and in the anthers being either introrse or extrorse, and always dehiscing longitudinally. The chief distinctive character between the two orders lies in the different æstivation of their corollas.

Distribution, &c.—They abound in tropical regions, but some are found in most parts of the world except in the coldest regions. *Examples:*—Nicotiana, Datura, Schizanthus, Salpiglossis, Petunia, Hyoscyamus, Atropa, Lycium, Solandra, Brunsfelsia. Miers enumerates 38 genera. This order with the preceding contains about 1050 species.

Properties and Uses.—Many plants of this order have powerful narcotic properties; hence several are very poisonous.

Nicotiana.—The leaves of various species and varieties supply the different kinds of Tobacco, now in such general use in some form or other in nearly every part of the globe. Mr. Crawford estimated the consumption of Tobacco in the British Islands in 1851 at 28,062,978 lbs., being at the rate of 16·86 oz.

per head of the population. He also estimated the total annual production at 2,000,000 of *tons*, which, at the value of 2*d*. per pound, would amount to 37,000,000*l*. sterling. The consumption of tobacco in this country has enormously increased of late years, and is still increasing. Tobacco owes its properties to the presence of an alkaloid called *Nicotina* which is a most energetic poison, a volatile oil (*nicotianin*), and an *empyreumatic oil*. Tobacco has been employed in medicine as a local stimulant, and as a sedative, antispasmodic, emetic, laxative, and diuretic. The principal kinds of Tobacco are the American, from *N. Tabacum;* the Shiraz or Persian, from *N. persica;* the Syrian and Turkish, from *N. rustica;* Cuba and Havannah, from *N. repanda;* and Orinoko, from *N. macrophylla*.

Datura Stramonium, Thorn-apple.—A narcotic property is possessed by all parts of the plant, and is especially developed in the seeds. Its medicinal effects resemble those of Belladonna. It is employed as an anodyne and antispasmodic. In *spasmodic asthma*, smoking the herb, or inhalation from its infusion in warm water, has frequently given great relief, but its use requires much caution, as it has in some instances produced fatal results. A strong decoction of the leaves in water is used in Cochin China as a remedy in hydrophobia, in which disease it is reputed to be very efficacious. Stramonium owes its principal activity to the presence of a narcotic alkaloid called *daturia*, which much resembles *hyoscyamia* and *atropia*, the alkaloids of *Hyoscyamus niger* and *Atropa Belladonna*. Daturia is a powerful poison, and strongly dilates the pupil. *D. Tatula*, *metel*, *ferox*, *fastuosa*, and *sanguinea*, have similar properties to the *D. Stramonium*. The fruit of *D. sanguinea*, the Red Thorn-Apple, is in use among the Indians of the Andes, and in Central America, in the preparation of narcotic drinks, the use of which produces a peculiar excitement, and enable them, they believe, to have communication with the spirits of their ancestors.

Hyoscyamus niger, Henbane.—The whole herb possesses narcotic properties, and is employed medicinally as a narcotic, anodyne, and soporific. Its activity is essentially due to the presence of the alkaloid *hyoscyamia*, which is a powerful poison resembling atropia and daturia, and like them it causes dilatation of the pupil. Two varieties of Henbane are commonly cultivated, the Annual and the Biennial; the latter of which is generally regarded as the most active in its properties.

Atropa Belladonna, Deadly Nightshade or Dwale, is a powerful poison. It is employed internally as an anodyne and antispasmodic, and externally for dilating the pupil. It owes its activity to a peculiar alkaloid called *atropia*, which is frequently employed instead of *Belladonna* to produce dilatation of the pupil, and for other purposes. Atropia is a most powerful poison.

Mandragora officinalis, the true Mandrake.—The roots have a fancied resemblance to the human form, hence their name. This Mandrake must not be confounded with the roots of *Bryonia dioica*, which are also sometimes so named. (See p. 548.) Mandrake is an acro-narcotic poison, and was used by the ancients as an anæsthetic. The plant is called Devil's-apple by the Arabs. Mandrake is considered to be the Dudaim of Scripture.

Natural Order 156. OLEACEÆ.—The Olive Order (*figs.* 979—981).—Trees or shrubs. *Leaves* opposite. *Flowers* usually perfect, or rarely unisexual. *Calyx* persistent, 4-cleft (*figs.* 979 and 980), sometimes obsolete (*fig.* 426), inferior (*fig.* 981). *Corolla* regular, 4-cleft (*fig.* 979), or of 4 distinct petals (*fig.* 980), or absent (*fig.* 426); *æstivation* valvate (*fig.* 979). *Stamens* usually 2 (*figs.* 426 and 980), rarely 4. *Ovary* (*figs.* 979 and 981) 2-celled, with 2 suspended ovules in each cell. *Fruit* fleshy or dry, often 1-seeded. *Seeds* with abundant fleshy albumen; *embryo* straight.

Distribution, &c.—They are principally natives of temperate regions, but a few occur within the tropics. *Examples:*—Olea, Phillyrea, Ligustrum, Fraxinus, Ornus, Syringa. There are 21 genera, and 130 species.

Properties and Uses.—The barks of many plants of this order

Fig. 979.

Fig. 980.

Fig. 981.

Fig. 979. Diagram of the flower of Lilac (*Syringa vulgaris*).—— *Fig.* 980. Flower of the Manna Ash *Ornus europœa* or *Fraxinus Ornus*, with 4-cleft calyx; corolla with 4 distinct petals; 2 stamens; and pistil.—— *Fig.* 981. Vertical section of calyx and pistil of the Privet (*Ligustrum vulgare*).

are tonic and febrifugal. The mild purgative called Manna is obtained from several species. The pericarp of the Common Olive yields the well-known Olive Oil. Some species are remarkable for the hardness of their wood.

Olea europœa, the Olive. — The ripe fruit has a very fleshy pericarp which yields by expression a fixed oil, known as Olive Oil, which is largely used for dietetical purposes, in the arts, and in medicine. In medicine it is principally employed externally, either by itself, or in composition with other substances. When administered internally, it is *nutrient*, *emollient*, *demulcent*, and *laxative*. The *olives* used as a dessert, are prepared by first soaking the green unripe fruit in water to deprive them of a portion of their bitter flavour, and then preserving them in a solution of salt slightly aromatised. The *leaves* and *bark* of the Olive-tree have been highly extolled by some writers for their tonic and febrifugal properties, and they certainly deserve more attention as remedial agents than they have hitherto obtained in this country. The substance called *olive gum* or *olivile* is a resinous exudation from the Olive-tree. It was formerly employed in medicine, but at present is not applied to any useful purpose. The *wood* of the Olive is much employed for cabinet-work. The flowers of *Olea fragrans* are used in China to give odour and flavour to a particular kind of tea.

Fraxinus excelsior, the Common Ash, has a febrifugal bark. The leaves are reputed to possess cathartic properties. It also yields a small quantity of manna, especially when growing in a warm climate. The wood possesses much strength and elasticity combined with lightness, hence it is much used for ladders, poles, and for agricultural implements, &c. The sweet concrete exudation known as manna, is obtained by making incisions into the stems of two or more species of *Fraxinus*. There is some uncertainty as to the number of species from which our supplies are derived; but they are chiefly from *Fraxinus Ornus* or *Ornus europœa*, and *F. rotundifolia* or *Ornus rotundifolia*. These plants are natives of Calabria, Apulia, and Sicily. Manna is a mild agreeable laxative. It owes its properties to *mannite*, and a peculiar *resin*. *Fraxinus chinensis* is the tree upon which the insect (*Coccus Pe-la*) producing the White Wax of China, feeds.

Syringa vulgaris, the Lilac, has a bitter, tonic, and febrifugal bark.

Natural Order 157. Jasminaceæ. — The Jasmine Order. — *Shrubs*, often twining. *Calyx* persistent, with 5—8 divisions. *Corolla* regular, 5—8-partite; *æstivation* imbricated. *Stamens* 2,

included. *Ovary* 2-lobed, 2-celled, with 1—4 erect ovules in each cell. *Fruit* a capsule or a berry. *Seeds* with very little or no albumen; *embryo* erect.

Distribution, &c.—Chiefly natives of the East Indies, but a few species are found in several other warm regions of the globe. *Examples*:—Jasminum, Nyctanthes. There are 6 genera, and about 100 species.

Properties and Uses.—The flowers are generally fragrant. The volatile oil of jasmine, which is used in perfumery, is chiefly obtained by distillation from the flowers of *Jasminum officinale* and *grandiflorum.* The leaves and roots of some species of *Jasminum* are reputed bitter, and have been employed for various purposes, but generally speaking the order contains no active medicinal plants. The flowers of *Nyctanthes arbor-tristis* are employed in India for dyeing yellow.

Natural Order 158. SALVADORACEÆ.—The Salvadora Order.—Shrubs or small trees. *Leaves* opposite, entire, leathery. *Flowers* small, panicled. *Calyx* of 4 sepals. *Corolla* 4-partite, membranous. *Stamens* 4. *Ovary* 1-celled; *stigma* sessile. *Fruit* fleshy, 1-celled, with a solitary erect seed. *Albumen* none.

Distribution, &c.—Natives of India, Syria, and North Africa. *Examples*:—Salvadora, Bouea. There are 4 genera belonging to this order.

Properties and Uses.—Some are acrid and stimulant. The only plant of any importance is *Salvadora persica*, which Dr. Royle has proved to be the Mustard-tree of Scripture. The fruit of this is edible, and resembles in taste garden Cress. The bark of the root is acrid, and is employed as a blistering agent in India. The leaves are reputed to be purgative

Natural Order 159. MYRSINACEÆ.—The Myrsine Order.—Trees or shrubby plants. *Leaves* coriaceous, smooth, exstipulate. *Flowers* small, perfect or unisexual. *Calyx* and *corolla* 4—5-partite. *Stamens* corresponding in number to the segments of the corolla and opposite to them, sometimes there are 5 sterile petaloid alternate ones; *anthers* dehiscing longitudinally. *Ovary* superior or nearly so, 1-celled; *placenta* free central, in which the ovules are imbedded. *Fruit* fleshy. *Seeds* 1, 2, or many; *albumen* abundant, horny.

Distribution, &c.—Chiefly natives of the islands of the southern hemisphere. *Examples*:—Mæsa, Embelia, Myrsine, Ardisia. Theophrasta. There are 32 genera, and 320 species.

Properties and Uses.—Of little importance. The fruits and seeds of some species are pungent. The fruit of *Myrsine africana* is used by the Abyssinians mixed with barley, as food for their asses and mules. The seeds of *Theophrasta Jussiæi* are used in St. Domingo in the manufacture of a kind of bread.

Natural Order 160. ÆGICERACEÆ.—The Ægiceras Order.—*Diagnosis.*—This order includes but one genus of plants. There

are 5 species; these inhabit sea-shores in tropical regions, and root from their seed-vessels into the mud, like Mangroves. The genus *Ægiceras* differs from Myrsinaceæ in its anthers dehiscing transversely; in having a follicular fruit; and in the seeds being without albumen.

Natural Order 161. PRIMULACEÆ. — The Primrose Order. (*figs.* 982—984).—Herbs. *Leaves* (*fig.* 371) simple, exstipulate.

Fig. 982.

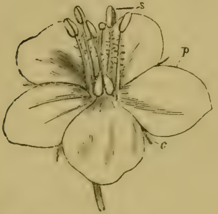


Fig. 983.

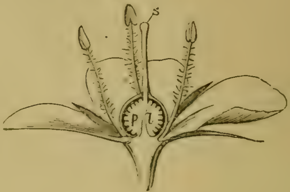


Fig. 984.

Fig. 982. Flower of *Anagallis*. *c.* Calyx. *p.* Petals. *s.* Stamens.——*Fig.* 983. Vertical section of the flower of Pimpernel (*Anagallis*). *pl.* Free central placenta. *s.* Style and capitate stigma.——*Fig.* 984. Vertical section of the seed of the *Primula elatior*. *t.* Integuments. *p.* Albumen. *e.* Embryo. *h.* Hilum.

Flowers regular, perfect (*figs.* 467 and 982). *Calyx* (*figs.* 443 and 467) 4—5-cleft, persistent, inferior (*fig.* 983), or partly superior. *Corolla* (*figs.* 467 and 982) 4—5-cleft, very rarely absent. *Stamens* (*fig.* 982, *s*) equal in number to the segments of the corolla, and opposite to them. *Ovary* superior (*fig.* 443), or rarely partly inferior, 1-celled (*fig.* 983); *placenta* free central (*figs.* 620 and 983); *style* 1 (*figs.* 443 and 983); *stigma* capitate (*figs.* 567 and 983). *Fruit* capsular (*fig.* 692), with transverse or valvular dehiscence. *Seeds* (*fig.* 984) numerous, with fleshy albumen; *embryo* placed transversely to the hilum.

Distribution, &c. — They principally inhabit cold and temperate regions in the northern parts of the globe. They are rare in the tropics, where they are only found on the sea-shore or in mountainous districts. *Examples*:— Primula, Cyclamen, Glaux, Anagallis, Hottonia, Samolus.

Properties and Uses.—Of no particular importance except for the beauty of their flowers. The flowers of the Cowslip (*Primula veris*), are sedative and diaphoretic, and are sometimes employed in the manufacture of a soporific wine. The roots of Cyclamens are acrid, especially those of *Cyclamen hederæfolium*, which have been used as a drastic purgative and emmenagogue.

The Cyclamens are commonly known under the name of Sowbreads from their being eaten by wild boars in Sicily.

Natural Order 162. PLUMBAGINACEÆ. — The Leadwort or Thrift Order (*figs.* 985, 986). — Herbs or under-shrubs. *Leaves* entire, exstipulate. *Flowers* regular (*fig.* 985). *Calyx*

Fig. 985.

Fig. 986.

Fig. 985. Diagram of the flower of a *Plumbago*.——*Fig.* 986. Essential organs of *Plumbago*.

tubular, plaited persistent, 5-partite (*fig.* 985). *Corolla* (*fig.* 985) membranous, 5-partite, or of 5 petals. *Stamens* (*figs.* 622, 985 and 986) 5, opposite the petals, to which they are attached in the polypetalous corolla, or hypogynous and opposite to the divisions of the monopetalous corolla. *Ovary* 1-celled (*figs.* 622 and 985); *ovule* solitary, suspended from a long cord which arises from the base of the cell (*fig.* 622); *styles* (*fig.* 986) usually 5, sometimes 3 or 4. *Fruit* utricular, or dehiscing by valves at the apex. *Seed* solitary; *embryo* straight; *albumen* mealy, and small in quantity.

Distribution, &c.—Chiefly found growing on the sea-shore and in salt marshes in various parts of the globe, but the mass of the order inhabit temperate regions. *Examples:*—Statice, Armeria, Plumbago. There are 11 genera, and 231 species.

Properties and Uses.— Of little importance, but acridity and astringency appear to be the most remarkable properties of the order.

Plumbago.— The roots of several species are acrid and vesicant when fresh, as those of *P. europæa*, Toothwort, *P. zeylanica, scandens*, and *rosea*. *P. toxicaria* is used as a poison in Mozambique.

Armeria vulgaris, Common Thrift.—The dried flowers are diuretic.

Statice caroliniana is called Marsh Rosemary in the United States, where its root is much employed as an active astringent.

Natural Order 163. PLANTAGINACEÆ. — The Ribwort Order (*figs.* 987 and 988). — Herbaceous plants, generally without stems (*fig.* 987). *Leaves* commonly ribbed and radical (*fig.* 987). *Flowers* usually spiked (*fig.* 390) and perfect, (*fig.* 988), or rarely solitary, and sometimes unisexual. *Calyx* persistent, 4-partite, imbricated (*fig.* 988). *Corolla* dry and membranous, persistent, 4-partite (*fig.* 988). *Stamens* equal in number to the divisions of the corolla, and alternate with them (*fig.* 988); *filaments* long and slender; *anthers* versatile. *Ovary* simple, 2 or 4-celled from the prolongation of processes from the placenta; *style* (*fig.* 988). 1. *Capsule* membranous, with transverse dehiscence; *placenta* free central. *Seeds* 1, 2, or more, with a mucilaginous testa; *embryo* transverse, in fleshy albumen

Fig. 987.

Fig. 988.

Fig. 987. Plant of a species of Rib-grass (*Plantago*), with radical ribbed leaves. —— *Fig.* 988. Flower of *Plantago*.

Distribution, &c. — They abound in cold or temperate climates, but are more or less diffused over the globe. *Examples;* — Littorella, Plantago. There are 3 genera, and 120 species.

Properties and Uses.—Unimportant. The seeds of *Plantago Psyllium, arenaria*, and *Cynops* are demulcent, and have been used like those of Linseed in the preparation of mucilaginous demulcent drinks. The leaves and roots of *P. lanceolata* and some other species are slightly bitter and astringent.

Natural Order 164. HYDROPHYLLACEÆ.—The Hydrophyllum Order. — Herbs, bushes, or small trees. *Leaves* usually hairy, lobed, and alternate. *Flowers* either solitary, stalked, and axillary; or arranged in circinate racemes or spikes. *Calyx* persistent, 5-partite. *Corolla* regular, 5-cleft. *Stamens* equal in number to, and alternate with the segments of the corolla. *Ovary* simple, 1—2-celled, with 2 parietal placentas; *styles* and *stigmas* 2; *ovules* 2, or many. *Fruit* capsular, 2-valved, 2 or 1-celled, with a large placenta filling the cell. *Seeds* netted; *albumen* hard, abundant.

Distribution, &c. — Chiefly natives of the northern and most southern parts of the American continent. *Examples:* — Hy-

drophyllum, Nemophila, Eutoca, Hydrolea. There are 18 genera, and 77 species.

Properties and Uses.—Unimportant, except as showy garden plants.

Natural Order 165. BORAGINACEÆ.—The Borage Order (*figs.* 989 and 990).—Herbs or shrubs, with more or less rounded stems. *Leaves* (*fig.* 416, *a*) alternate, entire, usually rough. *Inflorescence* scorpioid (*figs.* 416—418). *Flowers* regular, symmetrical (*figs.* 416, *a*, and 990). *Calyx*, (*figs.* 989 and 990) persistent, 4—5-partite. *Corolla* (*figs.* 468 and 990) regular or nearly so, 4—5-partite, usually with scales in its throat, (*fig.* 468, *r*); *æstivation* imbricated. *Stamens* (*fig.* 990) equal in number to the lobes of the corolla and alternate with them. *Ovary* deeply 4-lobed (*fig.* 595), with a solitary ovule in each lobe; *style* 1 (*fig.* 595), basilar; *stigma* simple or bifid. *Fruit* consisting of 2 or 4 distinct achænia, placed at the bottom of the persistent calyx (*figs.* 685 and 989). *Seeds* exalbuminous; *embryo* straight, with a superior radicle.

Fig. 989.

Fig. 990.

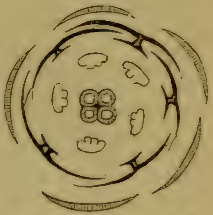


Fig. 989. Vertical section of the fruit of *Myosotis*. Two achænia are seen, and two have been removed.——*Fig.* 990. Diagram of the flower of Comfrey (*Symphytum officinale*).

Distribution, &c.—Chiefly natives of temperate regions in the northern hemisphere. *Examples:*—Cerinthe, Echium, Borago, Alkanna, Cynoglossum, Rochelia. There are 54 genera, and 683 species.

Properties and Uses.—The plants of this order are chiefly remarkable for their mucilaginous properties; hence they are mostly harmless, and possess little value as medicinal agents. Several species have roots of a reddish colour which renders them useful as dyeing agents.

Borago officinalis, Borage.—The root is mucilaginous and emollient. The herb imparts coolness to beverages in which it is steeped owing to the presence in it of nitrate of potash.

Symphytum officinale, Comfrey, is reputed vulnerary, The young leaves and shoots are sometimes eaten as vegetables. This plant contains a good deal of starch and mucilaginous matters, and Mr. Squire informs me, that when bruised, it forms an excellent bandage for broken limbs, &c. *S. asperrimum* has been recommended for cultivation in this country as food for pigs, &c.

Anchusa tinctoria, Alkanet, has a dark blood-red root, which is chiefly used to give colour to oils, &c., which are used in perfumery, and for dyeing woods, &c.

Natural Order 166. EHRETIACEÆ.—The Ehretia Order.—

Diagnosis.—The plants of this order resemble the Boraginaceæ in most of their characters, but they differ in having the carpels completely united so as to form a 2 or more celled ovary; in their terminal style; and drupaceous fruit. They are usually characterised also, by the presence of a small quantity of albumen in their seeds. This is, however, sometimes absent. By some authors, the Ehretiaceæ are made a sub-order of the Boraginaceæ.

Distribution, &c.—Chiefly tropical trees or shrubs. *Examples:*—Ehretia, Heliotropium. There are 14 genera, and 297 species.

Properties and Uses.—Unimportant. Some species of *Ehretia* have edible fruits. Some have a delicious odour, as the Peruvian Heliotrope (*Heliotropium peruvianum*).

Natural Order 167. Nolanaceæ.—The Nolana Order.—Herbs or shrubs. *Leaves* alternate, exstipulate. *Inflorescence* straight. *Calyx* 5-partite, persistent, with a valvate æstivation. *Corolla* regular, with a plaited æstivation. *Stamens* 5, opposite to the lobes of the calyx. *Ovary* composed of from 5—20 carpels, either distinct, or more or less combined into several sets; *style* on a fleshy disk, simple; *stigma* simple. *Fruit* composed of 5 or more separate achænia, or more or less combined; enclosed in the persistent calyx. *Seed* with a little albumen; *embryo* curved; *radicle* inferior.

Distribution, &c.—Natives exclusively of South America, especially of Chili. *Examples:*—Nolana, Alona. There are 6 genera, and 35 species.

Properties and Uses.—Unknown.

Natural Order 168. Labiatæ or Lamiaceæ.—The Labiate Order (*figs.* 991—996).—General Character.—Herbs (*fig.* 370) or shrubby plants, with usually square stems. *Leaves* opposite (*fig.* 370), commonly strong-scented, exstipulate. *Flowers* generally in axillary cymes, which are arranged in a somewhat whorled manner so as to form what are called verticillasters (*fig.* 370). *Calyx* persistent, tubular, 5 or 10-toothed,

Fig. 991.

Fig. 992.

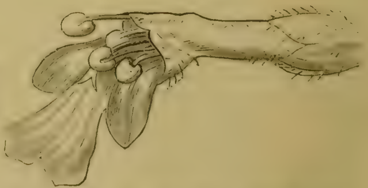


Fig. 991. Diagram of the flower of the White Dead-nettle (*Lamium album*).——*Fig.* 992. Flower of the common Bugle (*Ajuga reptans*).

regular; or irregular and bilabiate (*fig.* 447), with 3—10 divisions, the odd tooth or division always posterior (*fig.* 991). *Corolla* (*figs.* 470—473, and 992 and 993) bilabiate, with the upper lip undivided (*fig.* 470) or bifid (*figs.* 471 and 472), usually more or less arched over the lower lip (*fig.* 470), or sometimes nearly suppressed (*fig.* 992); the lower lip 3-lobed, with the odd lobe anterior (*fig.* 991). *Stamens* usually 4, didynamous (*figs.*

Fig. 993.

Fig. 994.

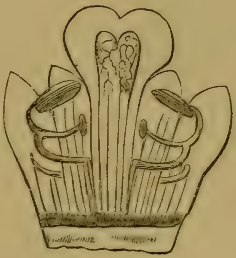


Fig. 995.

Fig. 996.

Fig. 993. Front view of the flower of *Lamium.*——*Fig.* 994. The corolla of the Garden Sage (*Salvia officinalis*) cut open.——*Fig.* 995. The corolla of the Horehound (*Marrubium vulgare*) cut open.——*Fig.* 996. Lobed ovary, style, and stigma of the Garden Sage (*Salvia officinalis*).

993 and 995), or rarely 2 by abortion (*fig.* 994); *anthers* 2-celled, or 1-celled by abortion; the filament or connective sometimes forked, with each branch bearing a perfect cell, or the cell on one side obsolete, or sterile (*fig.* 505). *Ovary* deeply 4-lobed (*figs.* 594 and 996), seated on a fleshy disk, with 1 erect ovule in each lobe; *style* 1, basilar (*figs.* 594 and 996); *stigma* forked (*fig.* 996). *Fruit* composed of from 1—4 achænia, enclosed by the calyx. *Seeds* erect, with little or no albumen; *embryo* erect, with flat cotyledons.

Diagnosis.—Herbs or shrubby plants with opposite exstipulate leaves. Flowers irregular, unsymmetrical. Calyx persistent. Corolla more or less bilabiate. Stamens didynamous, or 2 by abortion. Ovary deeply 4-lobed; style 1, basilar; stigma bifid. Fruit consisting of from 1—4 achænia, enclosed by the persistent calyx. Seeds erect, with little or no albumen.

Distribution, &c.—Chiefly natives of temperate regions. *Examples:*—Lavandula, Pogostemon, Salvia, Rosmarinus, Origanum, Scutellaria, Prostanthera, Nepeta, Lamium, Marrubium, Stenogyne, Ajuga. There are 129 genera, and 2350 species.

Properties and Uses.—The plants of this order are altogether free from any deleterious qualities. They abound in volatile oil frequently containing a *Stearoptene*; hence they are commonly aromatic, carminative, and stimulant. All labiate plants also contain more or less of a *bitter extractive matter*, and many of them possess an *astringent principle*, hence they are frequently tonic and stomachic. Several are used in perfumery on account of their agreeable odours; and many are employed by the cook for flavouring, &c., such as *Thymus vulgaris* (Common or Garden Thyme), *Thymus citriodorus* (Lemon Thyme), *Salvia officinalis* (Sage), *Origanum vulgare* (Common Marjoram), *Majorana hortensis* (Sweet Marjoram), *Satureja montana* (Winter Savory), *Satureja hortensis* (Summer Savory), &c. The fleshy underground stems of *Stachys palustris* and of a species of *Ocymum* are edible.

Ocymum album is used in India as Tea, which is known as Toolsie Tea.

Lavandula.—The flowering heads of *L. vera*, Common Lavender, yield by distillation with water English Oil of Lavender, which is largely used in perfumery; and also in medicine as a stimulant, stomachic, and carminative. The flowers are also employed as a sternutatory. The flowering heads of *L. spica* or *latifolia*, French Lavender, yield Oil of Spike or Foreign Oil of Lavender, which has a much less agreeable odour than the English Oil, and is not employed medicinally, but principally by painters and varnish-makers, and to adulterate English Oil of Lavender. *L. Stœchas* also yields by distillation an essential oil, which is commonly distinguished as the True Oil of Spike.

Pogostemon Patchouli, Pucha-Pat or Patchouly.—This plant is a native of Penang and the Malayan peninsula. The dried tops are imported and yield by distillation a strongly-scented volatile oil, called Oil of Patchouli, which has been much employed in perfumery. The coarsely powdered herb is also used for making *sachets*. The odour of Chinese or Indian Ink has been erroneously stated to be due to Patchouli.

Mentha, Mint.—Several species are used in medicine, and as *sweet herbs*. Three are officinal, namely, *M. viridis*, Spearmint, *M. piperita*, Peppermint, and *M. Pulegium*, Pennyroyal. They all possess stimulant and carminative properties. *M. rotundifolia*, *aquatica*, *arvensis*, *&c.* have similar properties.

Salvia officinalis, Common or Garden Sage.—The leaves were formerly much employed as tea. An infusion of Sage is much used in the United States as a gargle in common sore throat and when the uvula is relaxed. It is also stimulant, carminative, and anti-emetic. Sage is also much used by the cook as a flavouring agent, &c.

Rosmarinus officinalis, Common Rosemary.—The flowering tops contain a volatile oil, which imparts to them stimulant and carminative properties. Rosemary is however chiefly used in perfumery, and by the hairdresser. The flavour of Narbonne Honey is said to be due to the bees feeding on the flowers of this plant. The dried leaves are sometimes employed as a substitute for Chinese Tea.

Monarda punctata, Horsemint. — The herb is used medicinally in the United States. In its properties it resembles the ordinary mints, but it is more stimulating. *M. fistulosa* is said to be febrifugal. The leaves of *M. didyma* and *purpurea* are used in North America as tea under the name of Oswego Tea. The flowers of *Monarda didyma* are said to contain the same colouring principle as cochineal, and may be used for the preparation of carmine.

Origanum vulgare, Common or Wild Marjoram, has similar properties to the other labiate plants. The dried leaves have been employed as a substitute for Chinese Tea. Mr. Hanbury has shown that the red volatile oil sold usually in the shops as *Oleum Origani* or *Oil of Thyme*, is obtained by distillation from *Thymus vulgaris*. This oil is imported from the south of France. Several species of *Origanum* are used by the cook, as *O. vulgaris*, Common Marjoram, *O. Majorana* or *Majorana hortensis*, Sweet Marjoram, &c.

Hedeoma pulegioides, American Pennyroyal, is much used in the United States as an emmenagogue, and also occasionally as a stimulant and carminative.

Micromeria theasinensis is used in France as a substitute for Chinese Tea.

Melissa officinalis, Common Balm, possesses mild stimulant properties. It is used as a diaphoretic in fevers, as an exhilarating drink in nervous affections, and as an emmenagogue.

Marrubium vulgare, Common Horehound, is much employed as a domestic remedy in coughs, &c.

Natural Order 169. VERBENACEÆ. — The Vervain Order. — Herbs, shrubs, or trees. *Leaves* opposite or alternate, exstipulate. *Calyx* persistent, tubular. *Corolla* usually more or less 2-lipped or irregular. *Stamens* 4, usually didynamous, or rarely equal; sometimes there are but 2 stamens; *anthers* 2-celled. *Ovary* (*fig.* 997) 2 or 4-celled; *style* 1, terminal (*fig.* 997); *stigma* simple or bifid. *Fruit* dry or drupaceous, composed of from 2—4 nucules, which when ripe usually separate into as many indehiscents-seeded achænia. *Seeds* erect or ascending, with little or no albumen, and an inferior radicle. Known at once from Labiatæ by their more coherent carpels and terminal style.

Fig. 997.

Fig. 997. Pistil of the Vervain. (*Verbena.*)

Distribution, &c. — They are found both in temperate and tropical regions. *Examples:* — Verbena, Lantana, Tectona, Clerodendron. There are 45 genera, and 663 species.

Properties and Uses. — Many of the plants are slightly aromatic and bitter, but there are no important medicinal plants included in this order. Some are valuable timber-trees. The fleshy fruits of some species are edible. The leaves of a few species are used as substitutes for Chinese tea. Many are cultivated in our gardens for the beauty of their flowers and for their fragrance, as the different species and varieties of *Verbena*, the *Aloysia* or *Lippia citriodora*, the Sweet Verbena or Lemon-plant, &c.

Stachytarpha jamaicensis is reputed to be purgative and anthelmintic. Its leaves are sometimes employed in Austria as a substitute for, or to adulterate, Chinese tea. This is known under the name of Brazilian tea.

Lantana pseudo-thea is used in the Brazils as tea, under the name of *Capitão da matto*. Some species of *Lantana* have edible fruits.

Tectona grandis, Indian Teak-tree or Indian Oak, is the source of the

very hard and durable wood known as East Indian Teak, which is employed in ship-building, &c.

Vitex.—Several species of this genus have acrid fruits, as those of *V. trifolia*, Wild Pepper, *V. Negundo*, and *V. Agnuscastus*.

Natural Order 170. MYOPORACEÆ.—The Myopora Order.—*Diagnosis.*—This order is sometimes considered as a sub-division of the Verbenaceæ, from which it can be scarcely separated. It only differs essentially from that order in having pendulous seeds, and a superior radicle.

Distribution, &c.—Chiefly natives of the southern hemisphere. *Examples:*—Myoporum, Bontia, Avicennia. There are 9 genera, and 42 species.

Properties and Uses.—Unimportant. The bark of *Avicennia tomentosa*, White Mangrove, and other species, are much used in Brazil for tanning. The species of *Avicennia* grow like Mangroves in salt-marshes.

Natural Order 171. SELAGINACEÆ.—The Selago Order.—Herbs or shrubs, with alternate exstipulate leaves. *Flowers* irregular, unsymmetrical, sessile, bracteated. *Calyx* persistent, usually monosepalous with a definite number of divisions, or rarely consisting of two distinct sepals. *Corolla* tubular, 5-partite. *Stamens* 4, or rarely 2; *anthers* 1-celled. *Ovary* superior; *style* 1, filiform; *ovules* solitary, pendulous. *Fruit* 2-celled, with 1 solitary pendulous seed in each cell. *Embryo* in a little fleshy albumen, with a superior radicle. In *Globularia* there is but one carpel.

Distribution, &c.—Chiefly natives of the Cape of Good Hope. The species of *Globularia* are however European plants. *Examples:*—Selago, Gymnandra, Globularia. There are 10 genera, and 120 species.

Properties and Uses.—Of little importance. The *Globularias* are purgative and emetic. The leaves of *Globularia Alypum* form the *Wild Senna* of Germany. In small doses they act as a tonic, and in full doses, as a safe, mild, and efficient purgative. They have been sometimes employed for the adulteration of Senna Leaves, and it has been supposed also in the process of *tanning*. They contain both tannic and gallic acids.

Natural Order 172.—PEDALIACEÆ.—The Pedalium Order.—Glandular herbs. *Leaves* entire, without stipules. *Flowers* axillary, usually large and irregular. *Calyx* 5-partite. *Corolla* bilabiate. *Stamens* didynamous with the rudiment of a fifth, included; *anthers* 2-celled. *Ovary* on a fleshy or glandular disk, 1-celled, with 2 parietal placentas; sometimes spuriously 4—6-celled; *style* 1; *stigma* divided. *Fruit* bony or capsular. *Seeds* wingless, without albumen; *embryo* with large cotyledons, and a short radicle.

Distribution, &c.—Chiefly tropical plants. *Examples:*—Martynia, Pedalium, Sesamum. There are 14 genera, and about 25 species.

Properties and Uses. — Chiefly remarkable for their oily seeds.

Sesamum orientale.—The seeds yield by expression a fixed oil which is much used in India. It is rarely imported, however, as it soon becomes rancid. It is said to be employed to adulterate Almond Oil. The Oil is known as Teel, Gingely, or Gingillie Oil.

Natural Order 173. — GESNERACEÆ. — The Gesnera Order. — Herbs or soft-wooded shrubs. *Leaves* wrinkled, exstipulate, generally opposite or whorled. *Flowers* irregular, showy. *Calyx* half-superior, 5-parted. *Corolla* 5-lobed. *Stamens* diandrous, or didynamous with the rudiment of a 5th; *anthers* 2-celled, frequently united. *Ovary* half-superior, 1-celled, surrounded by an annular fleshy disk, or by glands ; *style* 1. *Fruit* capsular or succulent, 1-celled, with 2-lobed parietal placentas. *Seeds* numerous, with or without albumen ; *embryo* with minute cotyledons, and a long radicle.

Division of the Order, &c. — The order has been divided into two sub-orders as follows:—

Sub-order 1. *Gesnereæ.* — Fruit partially adherent to the calyx. Seeds with a little albumen. *Examples :* — Gesnera, Achimenes, Gloxinia.

Sub-order 2. *Cyrtandreæ.* — Fruit not adherent to the calyx. Seeds exalbuminous. *Examples :*—Æschynanthus, Cyrtandra.

Distribution, &c. — Chiefly natives of warm or tropical regions. The *Gesnereæ* are all American; the *Cyrtandreæ* are more scattered. There are 69 genera, and about 275 species.

Properties and Uses. — Of little importance except for the beauty of their flowers, which are common objects of cultivation in this country. Some *Gesnereæ* have edible fruits.

Natural Order 174. CRESCENTIACEÆ. — The Crescentia or Calabash Tree Order. — Small trees. *Leaves* simple, alternate or clustered, exstipulate. *Flowers* irregular, growing out of old branches or stems. *Calyx* free, entire at first, afterwards splitting irregularly. *Corolla* somewhat bilabiate. *Stamens* didynamous with a rudimentary 5th; *anthers* 2-celled. *Ovary* surrounded by an annular disk, 1-celled; *placentas* 2—4, parietal; *style* 1. *Fruit* indehiscent, woody. *Seeds* large, numerous, enveloped in a pulp, without albumen ; *cotyledons* large, amygdaloid; radicle short.

Distribution, &c. — Natives exclusively of tropical regions. *Examples :* — Crescentia, Parmentiera, Colea. There are 11 genera, and 34 species.

Properties and Uses. —Unimportant. The sub-acid pulp of the fruit of *Crescentia Cujete*, the Calabash Tree, is eaten by the negroes in America, and its hard shell is used for bottles, forming floats, &c. The fruit of *Parmentiera edulis* is also eaten by the Mexicans, and that of *P. cerifera* is also greedily de-

voured by cattle in Panama. It resembles a candle in shape; hence the tree is named the Candle-tree.

Natural Order 175. BIGNONIACEÆ. — The Bignonia or Trumpet-flower Order. — Usually trees or shrubs, which are often twining or climbing, rarely herbs. *Leaves* exstipulate, usually opposite. *Inflorescence* terminal. *Flowers* irregular. *Calyx* entire or divided. *Corolla* 4—5-lobed. *Stamens* 2 or 4; *anthers* 2-celled. *Ovary* seated in a disk, 2—4-celled; *placentas* axile; *style* 1. *Fruit* 2-valved, capsular, 2—4-celled. *Seeds* numerous, sessile, large, winged; *albumen* none; *embryo* with large leafy cotyledons.

Distribution, &c. — Chiefly tropical plants. *Examples:* — Bignonia, Calosanthes, Tecoma, Jacaranda, Eccremocarpus. There are 44 genera, and 450 species.

Properties and Uses. — The chief interest of the plants in this order lies in their beautiful flowers. From the leaves of *Bignonia Chica* the Indians of South America obtain a red dye called Chica or Carajuru, which is used for painting their bodies and arrows, and for other purposes. This Chica must not be confounded with Chica or Maize Beer (see *Zea Mays*), and other Chicas, which are common drinks of the Indians in South America. Some species of *Tecoma* have astringent properties. The wood of several plants of the order is used in Brazil. The bark of *Jacaranda bahamensis* is used as an anthelmintic in Panama.

Natural Order 176. ACANTHACEÆ. — The Acanthus Order. — Herbs or shrubs. *Leaves* opposite, simple, exstipulate. *Flowers* irregular, bracteated. *Calyx* 4—5-parted, or consisting of 4—5 sepals, persistent, much imbricated; sometimes obsolete. *Corolla* lipped. *Stamens* 2, or 4 didynamous. *Ovary* seated in a disk, 2-celled; *placentas* parietal, although extended to the axis; *style* 1. *Fruit* capsular, 2-celled, with 1, 2, or many seeds in each cell. *Seeds* hanging by hard cup-shaped or hooked projections of the placenta, without wings; *albumen* none; *cotyledons* large and fleshy.

Distribution, &c. — Chiefly tropical. *Examples:* — Thunbergia, Ruellia, Goldfussia, Acanthus, Justicia. There are 155 genera, and 1450 species.

Properties and Uses. — Unimportant. Some species have beautiful flowers. Many are mucilaginous and bitter. From *Ruellia indigotica*, a blue dye is obtained in China. The species of *Acanthus* have lobed and sinuated leaves, and furnished the model of the Corinthian capital.

Natural Order 177. — SCROPHULARIACEÆ. — The Figwort Order. — *Herbs* or rarely shrubby plants, with generally opposite leaves. *Inflorescence* axillary. *Flowers* (*figs.* 999 and 1000) anisomerous, irregular. *Calyx* (*fig.* 1000), persistent, (*fig.* 693), 4—5-partite. *Corolla* more (*figs.* 474 and 475) or less (*figs.*

478 and 479) irregular, 4—5-partite; *æstivation* imbricate (*fig.* 1000). *Stamens* 2 (*fig.* 999), or 4 didynamous (*fig.* 547),

Fig. 999.

Fig. 1000.

Fig. 999. Flower of Speedwell (*Veronica*).——*Fig.* 1000. Diagram of the flower of Frogsmouth (*Antirrhinum majus*), with one bract below.

rarely 5 or with a rudimentary 5th; *anthers* introrse. *Ovary* usually 2-celled (*fig.* 1000), its component carpels being placed anterior and posterior; *style* 1 (*fig.* 999). *Fruit* usually capsular (*fig.* 693), rarely baccate, generally 2-celled; *placentas* axile. *Seeds* generally numerous, albuminous; *embryo* straight or slightly curved. The above definition is in accordance with the views of Mr. Miers, by whom the sub-order Salpiglossideæ of Bentham is placed in the new order Atropaceæ. (See *Atropaceæ.*)

Distribution, &c. — The plants of this order are found in all parts of the globe. *Examples:* — Calceolaria, Verbascum Antirrhinum, Scrophularia, Mimulus, Gratiola, Limosella, Veronica, Euphrasia, Rhinanthus, Pedicularis, Melampyrum. As above defined, there are about 160 genera, and 1700 species.

Properties and Uses. — The plants of this order must be regarded with suspicion, as some are powerful poisons. Many are bitter, others are astringent, some are purgative, emetic, or diuretic, and a few possess narcotic properties. A great many are cultivated in our gardens, &c. on account of the beauty of their flowers. Several of the Scrophulariaceæ are root-parasites, as *Melampyrum*, *Rhinanthus*, *&c.*; these turn black when dried.

Verbascum.—The leaves of *V. Thapsus*, Great Mullein, have emollient, demulcent, and slightly narcotic properties. Its seeds and those of *V. nigrum* are said to be employed by poachers to stupify fish in order that they may be readily taken.

Scrophularia nodosa.—The fresh leaves are sometimes used in the form of an ointment or fomentation, as an application in skin diseases and to indolent tumours, &c. The leaves and roots of this species and of *S. aquatica* are purgative, emetic, and are supposed to be slightly narcotic.

Gratiola officinalis, Officinal Hedge Hyssop, was formerly officinal in our pharmacopœias. It possesses purgative, emetic, and diuretic properties, and in large doses it is an acrid poison.

Capraria bifolia is used in Central America as tea.

Digitalis purpurea, Foxglove.—This is by far the most important medicinal plant in the order. The roots, leaves, and seeds are the most active parts of the plant, but the leaves only are now officinal in our pharmacopœias. Foxglove is largely used as a diuretic in dropsies, and as a sedative of the circulation in diseases of the heart, &c. In improper doses it is a deadly poison. It owes its activity essentially to the presence of a peculiar bitter principle, called *Digitaline*. Other species of *Digitalis* have similar properties to those of *D. purpurea*, but they do not appear to be so active.

Veronica officinalis.—The leaves have been employed in this country, and on the Continent, as a substitute for Chinese tea: hence the plant is sometimes called *Thé de l'Europe*.

Natural Order 178. Orobanchaceæ. — The Broom-rape Order. — Herbs of a more or less fleshy character growing parasitically on the roots of other plants. *Stems* scaly, but without any true green leaves. *Calyx* persistent, toothed. *Corolla* irregular, persistent; *æstivation* imbricate. *Stamens* 4, didynamous; *anthers* 1—2-celled. *Ovary* 1-celled; its component carpels being placed to the right and left of the axis; *placentas* 2—4, parietal; *style* 1. *Fruit* capsular. *Seeds* very numerous, minute, with fleshy albumen, and a very small embryo.

Distribution, &c.—Principally natives of Europe, northern Asia, North America, and the Cape of Good Hope. *Examples:* —Epiphegus, Orobanche, Lathræa. There are 14 genera, and 116 species.

Properties and Uses. — The presence of an astringent principle is the most marked property of the plants of this order, but they are altogether unimportant in a medicinal point of view. The root of *Epiphegus virginiana* is called Cancer-root, from its having been formerly used as an application to cancers. It formed an ingredient in a once celebrated North American nostrum, called Martin's Cancer Powder.

Natural Order 179. Lentibulariaceæ. — The Butterwort Order.—Herbs, growing in water, marshes, or wet places. *Leaves* radical, entire or divided into thread-like filaments bearing little pouches or air vesicles. *Flowers* irregular. *Calyx* persistent, 2-lipped. *Corolla* 2-lipped. *Stamens* 2, included; *anthers* 1-celled. *Ovary* 1-celled; *style* 1, short; *stigma* 2-lipped; *placenta* free central. *Fruit* capsular, 1-celled. *Seeds* minute, numerous, without albumen; *embryo* minute, with the cotyledons much smaller than the radicle.

Distribution, &c. — Natives of all parts of the globe, particularly tropical regions. *Examples:* — Utricularia, Pinguicula. There are 4 genera, and 175 species.

Properties and Uses. — Of little importance. *Pinguicula vulgaris* is termed Butterwort from the property its leaves possess of coagulating milk.

Artificial Analysis of the Natural Orders in the Sub-class COROLLIFLORÆ. Modified from Lindley.

*** A few Orders belonging to the other Sub-classes, the flowers of which are sometimes monopetalous, are also admitted into this analysis.

The numbers refer to the Orders.

1. Epigynæ.

A. Carpel solitary.
  a. Anthers united.
    Ovule solitary, pendulous . . . . . . *Calyceraceæ.* 128.
    Ovule solitary, erect . . . . . . *Compositæ.* 129.
  b. Anthers distinct.
    Fruit with 1 perfect cell, and 2 rudimentary ones. Seed exalbuminous . . . . *Valerianaceæ.* 126.
    Fruit 1-celled, and without any rudimentary one. Seed albuminous . . . . . . *Dipsacaceæ.* 127.
B. Carpels more than one.
  a. Anthers united.
    Leaves alternate . . . . *Lobeliaceæ.* 131.
  b. Anthers distinct.
   1. *Stamens* 2.
    Filaments not united to the style . . . *Columelliaceæ.* 125.
    Filaments united to the style . . . . *Stylidiaceæ.* 133.
   2. *Stamens more than* 2.
    Anthers opening by pores . . . . *Vacciniaceæ.* 134
    Anthers opening longitudinally.
     Stigma with an indusium . . . . *Goodeniaceæ.* 132.
     Stigma without an indusium.
      Leaves without stipules.
       Stamens definite.
        Leaves alternate. Corolla persistent *Campanulaceæ.* 130.
        Leaves opposite. Stem round . . *Caprifoliaceæ.* 122.
        Leaves verticillate. Stem square . *Galiaceæ.* 124.
       Stamens numerous . . . . . . *Belvisiaceæ.* 110.
      Leaves with stipules.
       Stipules interpetiolar. Flowers hermaphrodite . . . . *Cinchonaceæ.* 123.
       Stipules cirrhose. Flowers unisexual *Cucurbitaceæ.* 99.

2. Hypostamineæ.

A. Carpel solitary.
    Stigma indusiate. Leaves radical, entire . *Brunoniaceæ.* 135.
B. Carpels more than one.
  a. Anthers opening by pores.
    Herbs. Seeds with a loose-winged testa . *Pyrolaceæ.* 138.
    Shrubs. Seeds without wings. Anthers 2-celled . . . . *Ericaceæ.* 136.
  b. Anthers opening longitudinally.
   1. *Anthers 1-celled* . . . . *Epacridaceæ.* 139.
   2. *Anthers 2-celled.*
    Plants with dotted leaves . . . . . *Rutaceæ.* 59.
    Parasitic brown scaly plants . . . *Monotropaceæ.* 137.

3. Epipetalæ.

A. Flowers regular.
  a. Ovary lobed.
    Inflorescence scorpioidal. Æstivation of corolla imbricated . . . . *Boraginaceæ.* 165.
    Inflorescence straight. Corolla with a valvate æstivation. Leaves exstipulate . . . *Nolanaceæ.* 167.
    Inflorescence straight. Corolla with a flat æstivation. Leaves exstipulate. . . . . *Stackhousiaceæ.* 72.

b. Ovary not lobed.

1. *Carpels more than three, distinct or combined.*
Stamens equal in number to the petals and opposite them.
Stem herbaceous. Style 1. Fruit capsular, dehiscent . . . . *Primulaceæ.* 161.
Stem woody. Style 1. Fruit fleshy indehiscent . . . . *Myrsinaceæ.* 159.
Stem herbaceous or woody. Styles 5, (rarely 3 or 4), Fruit membranous . . *Plumbaginaceæ.* 162.
Stamens not opposite the petals if of the same number.
Carpels distinct.
Seeds numerous . . . . . . *Crassulaceæ.* 89.
Seeds few . . . . *Anonaceæ.* 4.
Carpels combined. Ovary 2 or more celled.
Ovules erect or ascending.
Æstivation of the corolla plaited. Fruit dry . . . . *Convolvulaceæ.* 151.
Æstivation of the corolla imbricate. Fruit fleshy . . . . . . *Sapotaceæ.* 142.
Ovules pendulous or suspended, or rarely partly ascending.
Stamens twice or four times as many as the lobes of the corolla, distinct . *Ebenaceæ.* 140.
Stamens equal in number to the lobes of the corolla. Filaments distinct. Anthers adnate . . . . . . *Aquifoliaceæ.* 141.
Stamens equal in number to the lobes of the corolla. Filaments distinct. Anthers versatile . . . . . . *Cordiaceæ.* 150.
Part of the ovules sometimes ascending. Filaments more or less cohering . *Styracaceæ.* 143.

2. *Carpels three, combined so as to form a 3-celled ovary.*
Stem herbaceous. Disk hypogynous . *Polemoniaceæ.* 153.
Stem woody. No disk . . . . . *Diapensiaceæ.* 146.

3. *Carpels two, combined, or more or less distinct.*
Stamens 2.
Corolla 4-cleft . . . . *Oleaceæ.* 156.
Corolla more than 4-cleft . . . . *Jasminaceæ.* 157.
Stamens 4 or more. Inflorescence scorpioidal.
Fruit capsular, 1-celled, or imperfectly 2-celled . . . . *Hydrophyllaceæ.* 164.
Fruit drupaceous. 2 or more celled . . *Ehretiaceæ.* 166.
Stamens 4 or more. Inflorescence straight.
Leafless plants. Parasitical . . . *Cuscutaceæ.* 152.
Leafy plants.
Leaves alternate.
Calyx in a broken whorl . . . . *Convolvulaceæ.* 151.
Calyx in a complete whorl.
Anthers united to the stigma . . *Asclepiadaceæ.* 149.
Anthers free from the stigma.
Placentas parietal . . . . . *Gentianaceæ.* 148.
Placentas axile.
Æstivation of corolla valvate or induplicato-valvate . . . . *Solanaceæ.* 154.
Æstivation imbricate or some modification of it . . . . . *Atropaceæ.* 155.
Leaves opposite, whorled, or clustered.
Anthers united to the stigma . . . *Asclepiadaceæ.* 149.
Anthers free from the stigma.
Leaves with stipules . . . . . *Loganiaceæ.* 145.
Leaves without stipules.
Stigma shaped like an hour-glass.
Æstivation of corolla contorted . *Apocynaceæ.* 144.

Stigma not contracted in the middle like an hour-glass.
Æstivation of corolla imbricate.
Placentas parietal . . . . *Gentianaceæ.* 148.
Æstivation of corolla valvate.
Placentas axile . . . . *Stilbaceæ.* 147.
4. *Carpel solitary.*
Stamens opposite the lobes or petals of the corolla . . . . *Plumbaginaceæ.* 162.
Stamens alternate to the lobes of the corolla.
Fruit 1-celled. Stigma sessile . . . *Salvadoraceæ.* 158.
Fruit spuriously 2-celled, or rarely 4-celled.
Style capillary . . . . *Plantaginaceæ.* 163.
B. Flowers irregular.
a. Ovary 4-lobed . . . . *Labiatæ.* 168.
b. Ovary not lobed.
1. *Carpel solitary* . . . . *Selaginaceæ.* 171.
2. *Carpels two.*
Fruit nucamentaceous.
Anthers 1-celled . . . . *Selaginaceæ.* 171.
Anthers 2-celled. Ovules erect.
Corolla imbricated in æstivation . . *Verbenaceæ.* 169.
Corolla valvate in æstivation . . . *Stilbaceæ.* 147.
Anthers 2-celled. Ovules pendulous . *Myoporaceæ.* 170.
Fruit capsular, or succulent.
Placentas parietal.
Leafless scaly brown parasites . . *Orobanchaceæ.* 178.
Leafy plants. Seeds with wings . . *Bignoniaceæ.* 175.
Leafy plants. Seeds without wings.
Fruit capsular or baccate. Cotyledons minute, radicle long . . . . *Gesneraceæ.* 173.
Fruit bony or capsular. Cotyledons large, radicle short . . . . *Pedaliaceæ.* 172.
Fruit woody with a pulpy interior. Cotyledons large, radicle short . *Crescentiaceæ.* 174.
Placentas axile.
Seeds without wings.
Albuminous . . . . *Scrophulariaceæ.* 177.
Exalbuminous. Seeds attached to hard placental processes . . *Acanthaceæ.* 176.
Seeds winged. Exalbuminous . . *Bignoniaceæ.* 175.
Placentas free central . . . . . *Lentibulariaceæ.* 179.

There are certain exceptions to the characters above given of the Corolliflorae and its sub-divisions. Thus among the Epigynæ, we sometimes find polypetalous corollas in *Caprifoliaceæ* and *Lobeliaceæ*, and hence such plants properly belong to Calycifloræ. The ovary is sometimes superior in *Goodeniaceæ*, thus resembling the Epipetalæ of the sub-class Corollifloræ. In the Hypostamineæ, polypetalous species occur in *Ericaceæ*, *Monotropaceæ*, *Pyrolaceæ*, and *Epacridaceæ*, which are therefore Thalamifloral. In *Epacridaceæ* also, the stamens sometimes adhere to the corolla, in the same way as in the orders of the Epipetalæ of Corollifloræ.

Among the Epipetalæ we find plants with polypetalous corollas occasionally, as in *Styracaceæ*, *Oleaceæ*, *Primulaceæ*, *Myrsinaceæ*, and *Plumbaginaceæ*. The stamens are also sometimes hypogynous in *Ebenaceæ*, *Primulaceæ*, and *Plumbaginaceæ*, and hence such plants resemble the Thalamifloræ if the petals are distinct, or if united the Hypostamineæ of the Corollifloræ.

Again, among the Epipetalæ we occasionally find the ovary inferior or partly so, in *Ebenaceæ*, *Styracaceæ*, *Myrsinaceæ*, *Primulaceæ*, and in *Gesneraceæ* always, and hence such plants belong to the Epigynæ of the Corolliforæ, or to the Epigynæ of the Calyciforæ, according as their petals are united or distinct.

In *Oleaceæ* and *Primulaceæ*, apetalous species occur, and therefore resemble the Monochlamydeæ.

Unisexual species are found in *Valerianaceæ*, *Compositæ*, *Ebenaceæ*, *Aquifoliaceæ*, *Myrsinaceæ*, and *Plantaginaceæ*.

Sub-class IV.—*Monochlamydeæ.*

This sub-class is commonly divided by botanists into two sub-divisions, called respectively, Angiospermia and Gymnospermia, but the plants of the latter group present such striking differences in their structural and physiological characters from those of other Dicotyledons, that we have placed them in a division by themselves under the name of the Gymnospermia at the end of the Monochlamydeous Orders.

Natural Order 180. POLYGONACEÆ.—The Buckwheat Order (*figs.* 1001, 1002).—Usually herbs with alternate leaves and ochreate stipules (*fig.* 254). (The stipules are, however,

Fig. 1001.

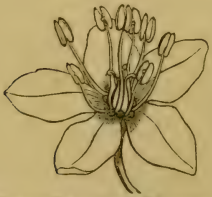


Fig. 1002.

Fig. 1001. Flower of a species of *Polygonum.*——*Fig.* 1002. Pistil of a species of *Rumex.*

occasionally absent, and the plants are sometimes shrubby.) *Flowers* perfect (*fig.* 1001), or sometimes unisexual. *Calyx* * free (*fig.* 1001), more or less persistent, imbricated *Stamens* (*fig.* 1001), hypogynous or perigynous ; *anthers* dehiscing lon-

* When there is but one floral envelope in Dicotyledonous plants, we call that the calyx, whatever be its colour or other peculiarity, in which nomenclature we follow the example of Lindley. By most botanists the term perianth is employed in such cases, but we use that name only in speaking of Monocotyledonous plants.

gitudinally. *Ovary* superior (*fig.* 1001), 1-celled; *styles* and *stigmas* 2—3 (*figs.* 1001 and 1002); *ovule* solitary (*figs.* 710 and 719), orthotropous. *Fruit* usually a triangular nut (*fig.* 1002). *Seed* solitary, erect; *embryo* (*fig.* 758) usually with farinaceous albumen, inverted, with a superior radicle.

Distribution, &c. — Generally diffused over the globe, and particularly so in temperate regions. *Examples:* —Eriogonum, Oxyria, Rheum, Polygonum, Coccoloba, Rumex, Triplaris, Brunnichia. There are about 34 genera, and 500 species.

Properties and Uses. — Chiefly remarkable for the presence of acid, astringent, and purgative properties. The acidulous character is principally due to the presence of oxalic acid. The fruits and roots of several are more or less nutritious.

Rheum, Rhubarb. — The species of this genus usually possess more or less purgative and astringent properties; this is especially the case with their roots, and hence they are largely used as medicinal agents. Various species of Rhubarb are indigenous or cultivated in different parts of the world, but the exact source of our officinal rhubarbs is at present unknown. Royle says, that "the Rhubarb country (from which they are derived) is in the heart of Thibet, within 95° of E. long, and 35° of N. lat., and as no naturalist has visited this part, and as neither seeds nor plants have been obtained thence, it is as yet unknown what species yields the Rhubarb." The principal kinds of Rhubarb are Russian or Turkey, Chinese or East Indian, Himalayan, and English. The Russian is the best, but its botanical source, as noticed above, as also that called Chinese, is unknown. Himalayan Rhubarb is the produce of several species, more especially of *R. Moorcroftianum*, *Webbianum*, and *Emodi*. English rhubarb is obtained from *R. Rhaponticum*, and is now extensively employed in the hospitals of this country, and in America, but it is not so active as the officinal kinds of rhubarb. The petioles of *R. Ribes* are used in the East in the preparation of sherbet. The petioles of *R. Rhaponticum* and other species are used for tarts and puddings. Their acidulous character is principally due to the presence of oxalic and malic acids. The roots of the species of *Rheum* contain abundance of oxalate of lime crystals (conglomerate raphides). (See p. 25.)

Polygonum. — The root of *P. Bistorta*, commonly called bistort root, is a powerful astringent, which property is due to the presence of tannic acid. Starch is also one of its constituents, hence it possesses nutritive properties, and is eaten when roasted in Siberia. The roots of *P. viviparum* are also used as food by the Esquimaux. The leaves of *P. Hydropiper* are very acrid, hence the common name of Water-pepper which is given to this plant. A yellow dye may be obtained from this species. From *P. tinctorium* a blue dye resembling indigo is obtained in France, &c. The Chinese produce a blue dye from several species of *Polygonum*.

Fagopyrum. — The fruits of *F. esculentum*, Common Buckwheat, of *F. tataricum*, and other species are used as a substitute for corn in the northern parts of Asia and Eastern Europe. The former species is cultivated in Britain as a food for pheasants.

Coccoloba uvifera, Seaside Grape. — From the leaves, wood, and bark of this species, a very astringent extract is obtained, which is commonly known as Jamaica Kino. The fruit is pleasantly acid and edible.

Rumex. — Several species possess acid properties owing to the presence of oxalic acid, especially *R. acetosa*, common Sorrel, *R. Acetosella*, *scutatus* and *Patientia*. They have been employed as pot-herbs, and for salads. *R. acetosa* is sometimes used medicinally for its refrigerant, diuretic, and antiscorbutic properties. In times of scarcity, it has been employed in Scandinavia as a substitute for bread. The root of *R. Hydrolapathum*, Great Water Dock, is astringent and antiscorbutic. The roots of *R. alpinus* are purgative, and were formerly employed instead of Rhubarb under the name of Monk's Rhubarb.

Natural Order 181. NYCTAGINACEÆ. — The Marvel of Peru

Order. — Herbs, shrubs, or trees, with the stems usually tumid at the joints. *Leaves* generally opposite. *Flowers* with an involucre. *Calyx* tubular or funnel-shaped, often coloured, plaited in æstivation, contracted towards the middle, its base persistent and becoming indurated and forming a spurious pericarp. *Stamens* 1 or many, hypogynous. *Ovary* superior, 1-celled, with a single ovule; *style* 1; *stigma* 1. *Fruit* a utricle, enclosed by the hardened persistent base of the calyx which forms a spurious pericarp. *Seed* solitary (*fig.* 759); *embryo* coiled round mealy albumen (*fig.* 759), with foliaceous cotyledons, and an inferior radicle.

Distribution, &c. — Natives exclusively of warm regions. *Examples:* — Boerhaavia, Mirabilis, Pisonia. There are 17 genera, and about 100 species.

Properties and Uses. — Chiefly remarkable for the presence of a purgative property in their roots; this is especially the case with *Mirabilis Jalapa* and *longiflora*. *M. Jalapa* was long erroneously regarded as the source of our medicinal Jalap. *M. dichotoma* is commonly known under the name of the Four-o'clock plant, from its opening its flowers in the afternoon.

Natural Order 182. Amaranthaceæ. — The Amaranth Order. — Herbs or shrubs. *Leaves* simple, exstipulate, opposite or alternate. *Flowers* crowded, spiked or capitate, bracteated, perfect, or occasionally unisexual. *Calyx* of 3—5 sepals, dry and scarious, persistent, often coloured. *Stamens* 5, hypogynous and opposite to the sepals, or a multiple of that number; *anthers* 2-celled or 1-celled. *Ovary* free, 1-celled, with 1 or more ovules; *style* 1 or none; *stigma* simple or compound. *Fruit* a utricle, a caryopsis, or a berry. *Seeds* 1 or more, pendulous; *embryo* curved round mealy albumen; *radicle* next the hilum.

Distribution, &c. — The plants of this order are most abundant in tropical regions, and are altogether unknown in the coldest climates. *Examples:* — Celosia, Amaranthus, Gomphrena. There are 46 genera, and 486 species.

Properties and Uses. — Unimportant. Some of the species have bright coloured persistent flowers, and are hence cultivated in our gardens, as *Amaranthus caudatus*, Love-lies-bleeding, *Amaranthus hypochondriacus*, Prince's-feathers, *Celosia cristata*, Cock's-comb, &c.

Natural Order 183. Chenopodiaceæ. — The Goosefoot or Spinage Order. — Herbs or undershrubs. *Leaves* exstipulate, usually alternate, rarely opposite. *Flowers* minute greenish, without bracts, perfect, polygamous, or diclinous. *Calyx* persistent (*fig.* 680), usually divided nearly to the base (*fig.* 425), imbricated. *Stamens* equal in number to the lobes of the calyx and opposite to them (*fig.* 425), or rarely fewer, hypo-

gynous, or inserted into the base of the lobes; *anthers* 2-celled, *Ovary* superior (*fig.* 425), or partly inferior, 1-celled, with a single ovule attached to its base; *style* (*fig.* 425) usually in 2—4 divisions, rarely simple. *Fruit* an achænium, or utricle (*fig.* 680), or sometimes baccate. *Seed* solitary; *embryo* with or without albumen, with the radicle towards the hilum. They are chiefly distinguished from the Nyctaginaceæ by their habit and non-bracteated flowers.

Distribution, &c.—More or less distributed over the globe, but most abundant in extra-tropical regions. *Examples:*—Salicornia, Atriplex, Spinacia, Beta, Chenopodium, Salsola. There are 72 genera, and 510 species.

Properties and Uses.—Several plants of this order inhabit salt-marshes, and yield by combustion an ash, called *barilla*, from which carbonate of soda was formerly principally obtained, but its use for this purpose has much fallen off of late years, in consequence of that substance being more readily extracted from other sources. The plants which thus yield barilla principally belong to the genera, *Salsola*, *Salicornia*, *Chenopodium*, and *Atriplex*. Many plants of the order are esculent, as Beet and Mangold-Wurzel; and some are used as pot-herbs, as Spinage (*Spinacia oleracea*), Garden Orach (*Atriplex hortensis*), and English Mercury (*Chenopodium Bonus Henricus*). The seeds of others again, are nutritious. Several contain volatile oil, which renders them anthelmintic, antispasmodic, aromatic, carminative, and stimulant.

Beta vulgaris, Common Beet.—The root of this plant is used as a salad, and as a vegetable for the table. It is largely cultivated on the continent and elsewhere as a source of sugar, and it is believed that at the present time, about 400 millions of pounds of beet-root sugar are annually produced on the continent of Europe. The Beet which is cultivated for this purpose is considered as a variety of the Common Beet, and is known as the Sugar Beet. A variety of the Common Beet (*Beta vulgaris*, var. *campestris*), is the Mangold-Wurzel, so much used as a food for cattle.

Chenopodium.—The seeds of *C. Quinoa* contain starch granules, which are remarkable for being the smallest hitherto noticed. They are known under the name of *petty rice*, and are common articles of food in Peru. *C. Bonus Henricus* as already mentioned, may be used as a pot-herb. The seeds of *C. anthelminticum*, Wormseed, are largely employed in North America for their anthelmintic properties. They also possess to some extent antispasmodic qualities. The herb generally has similar qualities. These effects are due to the presence of a highly odorous volatile oil. *C. ambrosioides* and *Botrys* are reputed to possess somewhat similar properties, but they are not so powerful. *C. Vulvaria* or *olidum*, Stinking Goosefoot, is an indigenous plant. It is a popular emmenagogue and antispasmodic. C. *ambrosioïdes* is employed in Mexico and Columbia as Tea, which is hence known as Mexican Tea.

Natural Order 184. BASELLACEÆ.—The Basella Order.—*Diagnosis.*—This is a small order of climbing herbs or shrubs closely allied to Chenopodiaceæ, but readily distinguished by having a coloured calyx with two rows of sepals, and perigynous stamens. There are 4 genera, and 12 species, all of which are tropical plants. *Basella rubra* and *alba*, are used in the East

Indies as a substitute for Spinage. From the former species a purple dye may be obtained. The fleshy roots of *Ullucus tuberosus* or *Melloca tuberosa*, are used in Peru as a substitute for the Potato.

Natural Order 185. SCLERANTHACEÆ.—The Scleranthus Order. —*Diagnosis.* —This is a small order of inconspicuous herbs, frequently considered as a sub-order of Paronychiaceæ, from which its plants are distinguished by the want of stipules; by being apetalous; in the tube of the calyx becoming hardened and covering the fruit, which is solitary and 1-celled; and in the stamens being evidently perigynous.

Distribution, &c. —They are valueless weeds found in barren places in the temperate regions of the globe. There are 4 genera, and 14 species, of which two species of *Scleranthus* are natives of Britain.

Natural Order 186. PHYTOLACCACEÆ. — The Phytolacca Order.—Herbs or undershrubs. *Leaves* alternate, entire, exstipulate. *Flowers* perfect, racemose. *Calyx* 4—5-parted. *Stamens* nearly or quite hypogynous, either equal in number to the divisions of the calyx and alternate with them, or more numerous; *anthers* 2-celled. *Ovary* superior, composed of 2 or more carpels, distinct, or more or less combined in a circle; *styles* and *stigmas* distinct, equal in number to the carpels. *Fruit* dry or succulent, each carpel of which it is composed containing 1 ascending seed; *embryo* curved round mealy albumen, with the radicle next the hilum.

Distribution, &c. —Natives principally of America, India, and Africa. *Examples:*— Giesekia, Phytolacca.

Properties and Uses. — An acrid principle is more or less diffused throughout the plants of this order; this is frequently destroyed by boiling in water. Some are emetic and purgative.

Phytolacca.—The roots of *P. decandra*, Poke or Pocan, are emetic and purgative. Its ripe berries have been used in chronic rheumatism and in syphilitic affections. Its young shoots boiled in water are eaten in the United States as Asparagus. The young shoots of *P. acinosa*, are also similarly eaten in the Himalayas.

Natural Order 187. SURIANACEÆ. —This name is given to an order of which there is but one known species, which is common on the sea-coast in the tropics. The order is supposed by Dr. Wright to be allied to Phytolaccaceæ, which it closely resembles in the structure of its ovary: but it is at once distinguished by the possession of petals, and by the stamens being opposite to the sepals. Its uses are unknown.

Natural Order 188. PETIVERIACEÆ. — The Petiveria Order. — *Diagnosis.* — This is another small order of plants which is placed by some botanists as a sub-order of the Phytolaccaceæ, with which it agrees in many particulars. It is distinguished from that order by having stipulate leaves, an ovary formed of a

single carpel, exalbuminous seeds, and a straight embryo with convolute cotyledons. They are natives of tropical America. Most of the plants are acrid, and some have a strong alliaceous odour. *Petiveria alliacea* is reputed sudorific and emmenagogue, and its roots are used in the West Indies as a remedy for toothache.

Natural Order 189. GYROSTEMONEÆ. — The Gyrostemon Order. — *Diagnosis.* — This is another small order of plants, which is considered by some botanists to be allied to Phytolaccaceæ, and is even sometimes associated with it. It is distinguished from that order by having unisexual flowers, the carpels arranged round a central column, 2 suspended seeds in each carpel, and a hooked embryo. They have no known uses.

This order and the three preceding ones include, (according to Lindley), 21 genera, and 78 species. They all require further investigation before their affinities can be well ascertained.

Natural Order 190. PIPERACEÆ. — The Pepper Order. — Herbs or shrubs with jointed stems. *Flowers* spiked, perfect, without floral envelopes, bracteated. *Stamens* 2 or more; *anthers* 1—2-celled. *Ovary* simple, 1-celled, with one erect orthotropous ovule; *stigma* sessile. *Fruit* more or less fleshy, 1-celled 1-seeded. *Seed* erect; *embryo* in a distinct fleshy sac at the apex of the seed, and on the outside of abundant albumen.

Distribution, &c. — Natives exclusively of tropical regions, especially in America, and the islands of the Indian Archipelago. *Examples:* — Peperomia, Macropiper, Chavica, Cubeba, Piper, Artanthe. There are 20 genera, and 600 species.

Properties and Uses. — The plants of this order are chiefly remarkable for acrid, pungent, aromatic, and stimulant properties. These qualities are especially to be found in their fruits, and are due to the presence of an acrid volatile oil and resin. Some are narcotic, and others are reputed astringent and febrifugal.

Macropiper methysticum.—The large rhizome of this plant is known in the South Sea Islands under the name of Ava, where it is largely used in the preparation of an intoxicating and narcotic liquor, called Ava or Cava. It is also used medicinally in chronic rheumatism and venereal affections.

Chavica.—The dried unripe female spikes of *C. Roxburghii* (*Piper longum*), constitute the Long Pepper of commerce which is obtained from our Indian possessions; those of *C. officinarum*, which are used in America, &c., are obtained from the Dutch colonies. The former is the kind generally used in this country. Long Pepper contains an acrid resin, a volatile oil, and a peculiar crystalline alkaloid called Piperine. It resembles Black Pepper in its effects, and is used in similar cases. It is chiefly employed for culinary purposes. Dried slices of the root and stem are used medicinally in India under the name of *Pippula Moola*. Other species of *Chavica* have similar properties, as *C. Chaba*, *pepuloides*, and *sylvatica*, and are used in India. The leaves of *C. Betle*, Betel Pepper, and *C. Siriboa* are chewed by the Malays and other eastern races, mixed with slices of the Betel Nut (*Areca Catechu*), and a little lime. Its use as above is considered to impart an ornamental red hue to the lips and mouth, and an agreeable odour to the breath, and is also

supposed to possess stimulant and narcotic properties, and to be a preservative against dysentery. (See *Areca*.)

Cubeba. — The dried unripe fruits of *Cubeba officinalis* constitute our officinal Cubebs. According to Blume, those of *C. canina* also form a portion of the Cubebs of commerce. They are the produce of Java and the adjoining islands. Cubebs are extensively employed in affections of the urino-genital organs, upon which they have a specific effect. In the East they are used as a stomachic. Their properties depend principally upon the presence of a volatile oil. They are frequently distinguished by the name of Tail Pepper, from the dried fruits having always a short stalk attached to them. The dried unripe fruits of *Cubeba Clusii*, African Cubebs or Black Pepper of Western Africa, are employed by the negroes of Sierra Leone, &c. as a condiment, and also as a medicinal agent. Their effects in genito-urinary affections do not appear to resemble those of the officinal Cubebs. According to Stenhouse they contain Piperine, and not the peculiar alkaloid of Cubebs, which has been termed Cubebine.

Piper nigrum, Black Pepper. — The dried unripe fruits of this plant constitute the Black Pepper of the shops. White Pepper is the same fruit in a ripened state divested of its external pulpy covering. The former is the more acrid and pungent, as these properties are lost to some extent in the process of ripening. Both kinds are extensively employed as condiments, and medicinally as stimulants and correctives. They are also thought to be febrifugal. They contain an acrid resin and a volatile oil, to which their acrid, pungent, aromatic, and stimulant properties are principally due; and Piperine, which is thought to possess febrifugal properties. *Piper trioicum* and some other species also produce good pepper.

Artanthe elongata, Matico. — The dried leaves of this plant constitute our Matico. Matico has been recommended as a topical application for arresting hæmorrhage from wounds, &c. It has been also employed internally as a styptic, but its effects, if any, thus administered, are very feeble. Its action appears to be strictly mechanical, like lint, felt, &c. In Peru Matico is employed for the same affections as Cubebs. It should be noticed that the name Matico is applied by the inhabitants of Quito, &c. to *Eupatorium glutinosum* (see *Eupatorium*). Other plants are also similarly designated in South America. The dried fruits of *A. adunca*, &c. are used in America as pepper. The spikes of fruit of *A. crocata* are used for dyeing yellow.

Natural Order 191. Chloranthaceæ. — The Chloranthus Order. — Herbs or undershrubs with jointed stems tumid at the nodes. *Leaves* simple, opposite, sheathing, with small interpetiolar stipules. *Flowers* spiked, achlamydeous, with scaly bracts, perfect or unisexual. *Stamen* 1, or more and united. *Ovary* 1-celled, with a solitary pendulous ovule. *Fruit* drupaceous. *Seed* pendulous, with a minute embryo (not enclosed in a distinct sac), at the apex of fleshy albumen, and an inferior radicle.

Distribution, &c.—Natives of tropical regions. *Examples:* — Hedyosmum, Chloranthus. There are 3 genera, and 15 species.

Properties and Uses. — Aromatic stimulant properties are the principal characteristics of the plants of this order.

Chloranthus. — The roots of *C. officinalis* and *brachystachys* have been employed in Java as stimulants in malignant fevers, &c., and for their antispasmodic effects. The leaves of *C. inconspicuus* are used in China to perfume tea. (See *Thea*.)

Natural Order 192. Saururaceæ. — The Saururus Order. — Marshy herbs. *Leaves* entire, alternate, stipulate. *Flowers* spiked, achlamydeous, perfect. *Stamens* 3—6, hypogynous, persistent. *Ovaries* 3—4, more or less distinct, or united,

with a few ascending ovules. *Fruit* either consisting of 4 fleshy indehiscent achænia, or capsular and 3—4-celled. *Seeds* ascending, with a minute embryo in a fleshy sac on the outside of hard mealy albumen.

Distribution, &c.—Natives of North America, Northern India, and China. *Examples:* — Saururus, Houttuynia. There are 4 genera, and 7 species.

Properties and Uses. — They have acrid properties, and have been reputed emmenagogue, but none of the plants possess any particular importance as remedial agents.

Natural Order 193. PODOSTEMACEÆ. — The Podostemon or River-weed Order. — Aquatic herbaceous plants with the aspect of Mosses or Liverworts. *Leaves* minute, or finely divided. *Flowers* minute, usually perfect, spathaceous, achlamydeous, or with an imperfect calyx, or with 3 sepals. *Stamens* 1 or many, hypogynous ; *anthers* 2-celled. *Ovary* superior, 2—3-celled ; *stigmas* 2—3 ; *ovules* ascending, numerous. *Fruit* capsular, ribbed, with parietal or axile placentation. *Seeds* numerous, exalbuminous, with a straight embryo.

Distribution, &c. — Principally natives of South America. *Examples:* — Hydrostachys, Lacis, Podostemon, Tristichia. There are 21 genera, and about 100 species.

Properties and Uses. — Unimportant. Some species of *Lacis* are used for food on the Rio Negro, &c., in South America, and other plants of the order are eaten by cattle and fish.

Natural Order 194. THYMELACEÆ. — The Mezereon Order. — Shrubs or very rarely herbs. *Leaves* entire, exstipulate. *Flowers* perfect (*fig.* 1003), or rarely unisexual. *Calyx* inferior (*fig.* 1003), coloured, tubular, 4—5-lobed; *æstivation* imbricate. *Stamens* perigynous (*fig.* 1003), twice as many as the divisions of the calyx, or equal in number to them, or fewer, in the two latter cases they are opposite to the lobes of the calyx; *anthers* 2-celled (*fig.* 1003), bursting longitudinally. *Ovary* superior (*fig.* 1003), simple, 1-celled (*fig.* 713), with a solitary suspended ovule (*fig.* 713). *Fruit* dry and nut-like, or drupaceous. *Seed* suspended; *albumem* none, or but small in quantity ; *embryo* straight, with a superior radicle.

Fig. 1003.

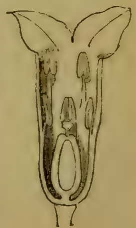


Fig. 1003. Vertical section of the flower of a species of *Daphne*.

Distribution, &c. — They are found more or less abundantly in all parts of the world, but especially in Australia and the Cape of Good Hope. *Examples:* —Dirca, Daphne, Pimelea, Lagetta, Hernandia. There are 43 genera, and about 300 species.

Properties and Uses. — The plants of this order are chiefly remarkable for the toughness and acridity of their bark. The

fruit of *Dirca palustris* is narcotic, and that of the plants generally of the order poisonous or suspicious, but the seeds of *Inocarpus edulis* are said to resemble Chestnuts when roasted. Several species of *Daphne*, *Pimelea*, and other genera, are handsome shrubby plants.

Daphne. — The *root-bark* of *D. Mezereum*, Mezereon or Spurge Olive, is officinal in the British pharmacopœias. It may be used as a vesicatory, and as a masticatory in toothache. It is however principally employed as a stimulant diaphoretic, alterative, and diuretic. It owes its properties to an acrid resin and an acrid volatile oil. The *stem-bark* possesses similar properties, but is generally considered as somewhat less active. The fruit is also very acrid and poisonous. The bark of *D. Gnidium* and *D. Laureola*, Spurge-Laurel, also possess acridity, and are sometimes substituted for the officinal bark, but they are not so active. The inner bark of *D. cannabina* and other species, are used in some parts of the world for making paper, &c.

Lagetta lintearia, Lace-Bark Tree.—The bark possesses somewhat similar properties to that of Mezereon. When macerated, it may be separated into laminæ, the number of which depends upon the age of the specimen; these have a beautiful lace-like appearance, hence its common name. It possesses great strength and may be used for making ropes, &c. It was at one time used in the West Indies for making the slave whips. Sloane states that caps, ruffles, and even whole suits of ladies' clothes, have been made from it. Lagetta cloth has been imported into Liverpool under the name of *guana*.

Natural Order 195. AQUILARIACEÆ.—The Aquilaria Order. —Trees, with entire exstipulate leaves. *Calyx* tubular or turbinate, 4—5-lobed, imbricate, persistent. *Stamens* perigynous, 10, 8, or 5, opposite to the lobes of the calyx when equal to them in number; *anthers* 2-celled, opening longitudinally. *Ovary* superior, 2-celled; *ovules* 2, suspended. *Fruit* usually 2-valved, capsular, sometimes succulent and indehiscent. *Seeds* usually 2, or rarely 1 by abortion; exalbuminous.

Distribution, &c.—Natives exclusively of tropical Asia. *Examples:* — Aquilaria, Gyrinopsis, Leucosmia. There are 6 genera, and 10 species.

Properties and Uses.—Some species yield a fragrant stimulant resin. The substance called Aloes-wood or Eagle-wood, is said to be the *Ahalim* and *Ahaloth* of the Old Testament, and the Aloe or Aloes of the New. It is obtained from *Aquilaria Agallochum* and *A. ovata* or *malaccensis*. It was formerly held in high repute as a medicinal agent in Europe, but its use is now obsolete. It is said to be useful as a cordial, and as a remedy for gout and rheumatism.

Natural Order 196. ELÆAGNACEÆ.—The Oleaster Order. —Trees or shrubs, with entire, exstipulate, usually scurfy (*fig.* 112.) leaves. *Flowers* mostly diœcious, rarely perfect. *Male flowers* amentaceous, bracteated. *Sepals* 2—4, or united. *Stamens* definite, perigynous. *Female flowers* with an inferior tubular calyx, and a fleshy disk, *æstivation* imbricate. *Ovary* superior, 1-celled, with a solitary ascending ovule. *Fruit* enclosed in the succulent calyx, indehiscent. *Seed* solitary, ascending, with thin albumen; *embryo* straight, with an inferior radicle.

Distribution, &c.—They are generally diffused in the northern hemisphere, and rare in the southern. *Examples* :—Hippophaë, Elæagnus. There are 4 genera, and 30 species.

Properties and Uses. — Unimportant. The fruits of *Elæagnus orientalis* are esteemed in Persia, and those of *E. arborea*, *conferta*, and others, are eaten in certain parts of India. Those also of *Hippophaë rhamnoides*, the Sea-Buckthorn, which is a native of England, are also edible, and have been employed in the manufacture of a sauce for fish, but their use requires caution, as they contain a narcotic principle.

Natural Order 197. PROTEACEÆ — The Protea Order. — Shrubs or small trees. *Leaves* hard, dry, exstipulate. *Flowers* perfect. *Calyx* inferior, 4-partite or of 4 sepals; *æstivation* valvate. *Stamens* perigynous, equal in number to the divisions of the calyx and opposite to them; *anthers* bursting longitudinally. *Ovary* simple, superior, 1-celled, with 1 or more ovules, ascending. *Fruit* dehiscent or indehiscent. *Seeds* exalbuminous, with a straight embryo, and an inferior radicle.

Distribution, &c.—Natives chiefly of Australia and the Cape of Good Hope. *Examples* :— Leucadendron, Protea, Conospermum, Franklandia, Persoonia, Grevillea, Hakea, Banksia, Dryandra. There are 46 genera, and 650 species.

Properties and Uses.—They are chiefly remarkable for the beauty or singularity of their flowers, and their evergreen foliage. The wood is largely employed at the Cape and in Australia for burning, and occasionally for other purposes, thus, that of *Protea grandiflora* is used at the Cape of Good Hope for waggon-wheels, hence the plant is named Wagenboom.

Natural Order 198. PENÆACEÆ. — The Penæa or Sarcocolla Order. — Evergreen shrubs, with opposite, exstipulate, imbricated leaves. *Flowers* perfect. *Calyx* inferior, bracteated, 4-lobed ; *æstivation* valvate or imbricate. *Stamens* perigynous, 4 or 8, alternate with the divisions of the calyx when equal to them in number. *Ovary* superior, 4-celled ; *style* 1 ; *stigmas* 4, with appendages on one side. *Fruit* 4-celled, dehiscent or indehiscent. *Seeds* varying in position, exalbuminous; *embryo* with very minute cotyledons.

Distribution, &c.— They are only found at the Cape of Good Hope. *Examples* : — Penæa, Sarcocolla, Geissoloma. There are 6 genera, and 21 species.

Properties and Uses. — Unimportant.—The gum-resin called Sarcocolla, is generally considered to be derived from one or more plants of this order, but its origin is doubtful, and is conjectured by Lindley to be yielded by an Umbelliferous plant.

Natural Order 199. LAURACEÆ. —The Laurel Order. — Trees or shrubs. *Leaves* exstipulate, usually alternate and dotted. *Flowers* generally perfect, sometimes imperfectly unisexual (*fig.* 1004). *Calyx* inferior (*fig.* 1004), deeply 4—

6-cleft, coloured, in two whorls, the limb sometimes obsolete; *æstivation* imbricated. *Stamens* perigynous, definite, some always sterile; *filaments* distinct, the inner ones commonly with glands at their base (*fig.* 529, *g,g*); *anthers* adnate, 2—4-celled, dehiscing by recurved valves (*fig.* 529, *v*). *Ovary* superior (*fig.* 1004), 1-celled, with 1 or 2 pendulous ovules (*fig.* 1004). *Fruit* a berry or a drupe. *Seeds* exalbuminous; *embryo* with large cotyledons, and a superior radicle.

Fig. 1004.

Fig. 1004. Vertical section of the female flower of *Laurus nobilis*, the Sweet Bay.

Distribution, &c.—They are chiefly natives of tropical regions, but a few occur in North America, and one (*Laurus nobilis*) in Europe. *Examples*:—Cinnamomum, Camphora, Persea, Agathophyllum, Mespilodaphne, Nectandra, Sassafras, Tetranthera, Laurus. There are 54 genera, and 450 species.

Properties and Uses.—The plants of this order are almost universally characterised by the possession of aromatic properties which are due to the presence of volatile oils; many of them are therefore employed as aromatic stimulants; others are narcotic. Some again act as sudorifics; and others are tonic, febrifuge, and astringent. Several have edible fruits, and many yield valuable timber.

Cinnamomum.—Cinnamon which is so much employed as a condiment, and medicinally as a cordial, stimulant, tonic, astringent, carminative, antispasmodic, and as an adjunct to other medicines, is obtained from *C. zeylanicum*. It chiefly consists of the inner bark. The best comes from Ceylon, and is obtained from branches of about three years old. It owes its properties to the presence of a volatile oil and tannin. This volatile oil is the oil of cinnamon of commerce. A concrete fatty substance is obtained in Ceylon by expression from the ripe fruits, which is called *Cinnamon Suet*. Royle supposes this to be the *Comacum* of Theophrastus. From the leaves of the Cinnamon tree a volatile oil is also distilled in Ceylon. It has an analogous odour and taste to that of oil of cloves. The Cinnamon tree is the *Kinnemon* or *Kinman* of the Bible. *C. Cassia*, a native of China, yields *Cassia-lignea* or the *Cassia bark* of commerce; this possesses analogous properties to Cinnamon, and like that bark yields by distillation a volatile oil, called *Oil of Cassia*, to the presence of which its properties are essentially due. *Cassia buds* of commerce which are now much used as a condiment, are reputed to be the flower-buds of the above plant. According to Martius, however, they are the produce of *C. aromaticum* and *C. dulce; C. Loureiri* is also stated to be one of their sources. Cassia-buds possess somewhat similar properties to Cassia lignea. The Cassia tree is the *Kiddah* or *Cassia* of the Bible. The bark called *Indian clove bark* is obtained from *C. Culilawan*. It possesses properties resembling Cassia. *Sintoc bark*, which has analogous properties, is the produce of *C. sintoc*. *C. nitidum* and *C. Tamala* yield the *folia malabathri* of India.

Camphora officinarum, the Camphor tree, is a native of China, Japan, and Cochin China. Camphor is obtained by boiling pieces of the roots, wood, and branches of the tea in water until the camphor begins to adhere to the stirring-rod, then the liquid is strained and allowed to stand till the camphor concretes, after which it is sublimed, and the camphor which is thus obtained is termed *crude camphor*, in which condition it is exported to Europe, &c., where it is afterwards purified by subliming again with a certain amount of lime, after

which process it is termed *refined camphor*. Camphor is a *stearoptene* or *solid volatile* oil. This kind of camphor is commonly distinguished from other camphors by the name of *Laurel*, *Common*, or *Officinal camphor*. In proper doses, camphor produces exhilarating and anodyne effects, for which purposes it is principally employed medicinally. In large doses it is narcotic and poisonous.

Persea.—The fruit of *P. gratissima* is in much repute in the West Indies. It is commonly known as the Avocado Pear. *P. indica*, a native of Madeira, yields a timber somewhat resembling mahogany.

Mespilodaphne pretiosa, a native of Brazil, yields the aromatic bark called *Casca pretiosa* by the Portuguese.

Cryptocarya moschata, yields a kind of *false* or *wild nutmeg* termed the Brazilian Nutmeg.

Agathophyllum aromaticum also yields a kind of false nutmeg, which is the Clove-Nutmeg of Madagascar or Ravensara nut. It is used as a spice.

Acrodiclidium Camara yields another false nutmeg, called in Guiana the Ackawa or Camara Nutmeg. Neither of the above wild nutmegs are imported into this country.

Nectandra.—*N. Rodiæi* is the Bibiru, Sipiri, or Greenheart-Tree, the wood of which is very hard and durable, and has been employed in ship-building, &c. *Beeberu* or *bibiru bark* is obtained from the above tree. It has been used of late years in medicine as a substitute for the cinchona-barks, possessing like them, tonic, antiperiodic, febrifugal, and astringent properties. These properties are due to the presence of a peculiar alkaloid called *Biberine* or *Bebeerine* which has nearly similar medicinal properties to quina, and is employed by itself, and in the form of a sulphate, as an economical substitute for sulphate of quinine. It is, however, generally regarded as less powerful. The *seeds* of the Bibiru contain starch ; this is mixed with an equal quantity of a species of decayed astringent wood, and a similar proportion of cassava pulp, and made into a kind of bread, which is used as food by the Indians, *Nectandra cymbarum* of Nees, the *Ocotea amara* of Martius, yields the substance called Brazilian Sassafras. The cotyledons of *N. Puchury major* and *minor* are imported from Brazil under the name of Sassafras-Nuts or Pichurim Beans, which are much esteemed as a flavouring for chocolate. During the continental war they were used as a substitute for nutmegs.

Dicypellium caryophyllatum yields Brazilian Clove-Bark or Clove Cassia Bark. It is occasionally imported, and used for mixing with other spices.

Oreodaphne.—Several species of this genus yield valuable timber, thus the *Sweet-wood* is the produce of *O. exaltata;* the *Til* of the Canaries, of *O. fœtens;* and the *Siraballi* of Demerara, is obtained from a species of *Oreodaphne* or some nearly allied genus.

Sassafras.—The root and wood of *S. officinale* under the name of Sassafras, are officinal. Sassafras is employed medicinally in this country and elsewhere, as a stimulant, diaphoretic, and alterative. From it the volatile oil of Sassafras is obtained. Sassafras pith is used in America as a demulcent like quince seeds, in place of which it is commonly employed in the United States.

Laurus nobilis, the Sweet Bay or Laurel, is said to be the *Ezrach* or Green Bay-tree of the Bible. It is the classic Laurel which was used by the ancients to make crowns for their heroes. The fruit is officinal, and is known under the name of Bay or Laurel berries. They are reputed to be aromatic, stimulant, and narcotic, but they are very rarely used in medicine. By distillation with water they yield a volatile oil, commonly known as the volatile oil of Sweet Bay. The substance called Expressed Oil of Bays or Laurel fat, is obtained from both the fresh and dry fruits by pressing them after they have been boiled in water. It is of a green colour, and a butyraceous consistence. *Laurel leaves* have somewhat similar properties to the fruit. From their aromatic properties they are used in cookery for flavouring. These leaves must not be confounded with those of the poisonous Cherry Laurel, already noticed (See *Cerasus* p. 535). Nothing certain is known of the source of the oil imported from Demerara under the name of Native Oil of Laurel or Laurel Turpentine. By some it is supposed to be derived from a plant of the order Lauraceæ, by others from one of the Coniferæ.

Natural Order 200. CASSYTHACEÆ.—The Dodder-Laurel Order. — *Diagnosis.* —This is a small order which has been

separated from the Lauraceæ by Lindley. The only important differences between the Lauraceæ and the Cassythaceæ consist in the plants of the latter being parasitical in their habit; in having scales in place of true leaves; and in their fruit being enclosed in a succulent calyx.

Distribution, &c.—Natives of tropical regions. There is only 1 genus—*Cassytha,* which contains 9 species. Their uses are unknown.

Natural Order 201. ATHEROSPERMACEÆ.—The Plume Nutmeg Order.—Trees with opposite exstipulate leaves. *Flowers* axillary, racemose, bracteated, diclinous or rarely perfect. *Calyx* tubular, with several divisions. *Male flowers* with numerous perigynous stamens; *anthers* 2-celled, opening by recurved valves. *Female flower* usually with abortive scaly stamens. *Carpels* numerous, distinct, each with a solitary erect ovule; *styles* and *stigmas* as many as the carpels. *Fruit* consisting of a number of achænia enclosed in the tube of the calyx and the persistent styles which have grown into feathery awns. *Seeds* erect, with a minute embryo at the base of fleshy albumen.

Distribution, &c.—Natives of Australia and Chili. There are but 3 genera, and 4 species, namely *Atherosperma* and *Doryphora* from Australia, and *Laurelia* from Chili.

Properties and Uses.—They are fragrant plants. The achænia of *Laurelia* somewhat resembles the common Nutmeg in their odour. A decoction of the bark of *Atherosperma moschata* is stated by Backhouse to be used in some parts of Australia as a substitute for China tea. The wood is also valuable as timber.

Natural Order 202. MONIMIACEÆ.—The Monimia Order.—*Diagnosis.*—Trees or shrubs, with opposite exstipulate leaves. *Flowers* axillary, diclinous. The flowers generally resemble those of the Atherospermaceæ, but they differ in always being unisexual; in the longitudinal dehiscence of their anthers; in the absence of feathery styles to the fruit; and in their ovules and seeds being pendulous.

Distribution, &c.—They are principally natives of South America, but are found also in Australia, Java, Madagascar, the Mauritius, and New Zealand. *Examples:*—Monimia, Citrosma, Boldoa. There are 8 genera, and 40? species.

Properties and Uses.—They are aromatic fragrant plants, but have no particular importance either in an economical or medicinal point of view.

Natural Order 203. MYRISTICACEÆ.—The Nutmeg Order.—Trees. *Leaves* alternate, exstipulate, entire, stalked, leathery. *Flowers* diclinous. *Calyx* leathery, 3—4-cleft; in the female flower, deciduous; *æstivation* valvate. *Male flower* with 3—12 stamens, or rarely more numerous; *filaments* distinct or monadelphous; *anthers*, 2-celled, extrorse, distinct or united, with longitudinal

dehiscence. *Female flower* of 1 or many carpels; or rarely 2, and distinct; each with 1 erect ovule. *Fruit* succulent. *Seed* arillate, with copious oily-fleshy ruminated albumen; *embryo* small, with an inferior radicle.

Distribution, &c.—Natives of tropical India and America. *Examples:*—Myristica, Virola, Hyalostemma. There are 5 genera, and 44 species.

Properties and Uses.—Aromatic properties are almost universally found in the plants of this order, more especially in their seeds. The bark and the pericarp are frequently acrid.

Myristica.—The valuable and well-known spices named Nutmegs and Mace, are both derived from *M. moschata* or *officinalis*. The Nutmeg tree is a native of the Molucca Islands, but it is now cultivated in many tropical regions. It bears pear-shaped fruits, commonly about the size of an ordinary peach, with fleshy pericarps; each fruit contains a single seed, surrounded by a lacerated envelope called an *arillode*, or commonly *mace;* this is scarlet when fresh, but becomes yellow afterwards. Beneath the mace we find a hard shell, and within this the nucleus of the seed invested closely by the endopleura, which also penetrates the substance of the albumen and divides it into lobes (ruminated albumen). This nucleus, or the seed divested of its shell and arillode, is our commercial nutmeg. The pericarp is commonly used as a preserve. Both nutmegs and mace are largely employed as condiments, but their use requires caution in those subject to apoplexy or other cerebral affections, as they possess narcotic properties. In medicine they are employed as stimulants, carminatives, and flavouring agents. Nutmegs yield when distilled with water a volatile oil, called Volatile or Essential Oil of Nutmegs. Mace under like conditions, also yields a volatile oil of nearly similar properties. The substance called Expressed Oil of Mace, Butter of Nutmegs, or Expressed or Concrete Oil of Nutmegs, is imported from the Moluccas, and is prepared by heating nutmegs, and afterwards submitting them to pressure. It consists of a small quantity of volatile oil mixed with two fatty substances. The Nutmegs thus described above, are frequently termed the True or Round Nutmegs, to distinguish them from those of an inferior quality, which are obtained from other species of *Myristica, &c.* One of these inferior nutmegs is found in commerce, it is called the Long or Wild Nutmeg. It occurs in three conditions, namely, without the hard shell and arillode, then termed the *long* or *wild nutmeg;* enclosed within the shell divested of its arillode (*long* or *wild nutmeg in the shell*); and within the shell and arillode (*long* or *wild nutmegs covered with mace*). These long nutmegs are said to be derived from *Myristica fatua* or *tomentosa*, and probably, also, to some extent, from *M. malabarica.* Both the long nutmeg and its mace, are very inferior to the similar parts of *M. moschata.* There are several other kinds of Nutmegs derived from different species of *Myristica*, which are in use in various parts of the world, but as they are much inferior in their qualities and are not found in commerce, it is unnecessary to allude to them here. We have already stated, that the fruits of some Lauraceous plants are known under the name of Nutmegs.

Natural Order. 204. BEGONIACEÆ.—The Begonia Order.—Herbs or low succulent shrubs. *Leaves* alternate, unequal-sided at the base (*fig.* 315), with large stipules. *Flowers* diclinous. *Calyx* superior. *Male flower* with 4 sepals, 2 of which are smaller and placed internal to the others. *Stamens* numerous, distinct, or coherent in a column; *anthers* 2-celled, clavate, with longitudinal dehiscence, clustered. *Female flower* with 5 or 8 sepals. *Ovary* inferior, winged, 3-celled, with 3 large projecting placentas meeting in the axis; *stigmas* 3, sessile, 2-lobed. *Fruit* winged, capsular. *Seeds* numerous, with a thin

reticulated testa, and without albumen. This order and the Datiscaceæ are placed by some botanists near to Cucurbitaceæ, to which they are certainly nearly allied.

Distribution, &c. — Natives chiefly of India, South America, and the West Indies. *Examples:* — Begonia, Diploclinium. There are 4 genera, and 160 species.

Properties and Uses. — They are reputed generally to possess astringent and bitter qualities, and occasionally to be purgative. None however, have any particular importance.

Natural Order 205. DATISCACEÆ. — The Datisca Order. — Herbs or trees. *Leaves* alternate, exstipulate. *Flowers* diclinous. *Male flower* with a 3 — 4-cleft calyx. *Stamens* 3 — 7; *anthers* 2-celled, linear, bursting longitudinally. *Female flower* with a superior 3 — 4-toothed calyx, and a 1-celled ovary, with 3 — 4 polyspermous parietal placentas. *Fruit* dry, opening at the apex. *Seeds* without albumen, minute, numerous.

Distribution, &c.—They are widely distributed over the globe. *Examples:* —Datisca, Tetrameles, Tricerastes. The above are the only genera: there are 4 species.

Properties and Uses.—Of little importance. *Datisca cannabina* is bitter and purgative. The root is employed in Cashmere as a yellow dye. Useful fibres might probably be obtained from the plants of this order.

Natural Order. 206. SAMYDACEÆ.—The Samyda Order. — Trees or shrubs. *Leaves* alternate, simple, evergreen, stipulate, usually with round or linear transparent dots. *Flowers* perfect. *Calyx* inferior, 4 — 5-partite. *Stamens* perigynous, 2, 3, or 4 times as many as the segments of the calyx; *filaments* united, some of them frequently sterile; *anthers* 2-celled. *Ovary* superior, 1-celled; *style* 1, filiform; *placentas* parietal, bearing numerous ovules. *Fruit* capsular, leathery, 1-celled. *Seeds* numerous, arillate, with oily or fleshy albumen; *embryo* large.

Distribution, &c.—Exclusively tropical, and principally American. *Examples:* — Samyda, Casearia. There are 5 genera, and 80 species.

Properties and Uses. — Of little importance. They are commonly bitter and astringent.

Natural Order 207. LACISTEMACEÆ. — The Lacistema Order. —Shrubby plants. *Leaves* simple, alternate, stipulate. *Flowers* in axillary catkins, perfect or unisexual. *Calyx* inferior, with several divisions, enclosed by a bract. *Stamen* 1, hypogynous, with a 2-lobed connective, each lobe bearing 1 cell of the anther, which bursts transversely. *Ovary* superior, seated in a disk, 1-celled, with numerous ovules attached to parietal placentas. *Fruit* capsular, 1-celled, 2—3 valved. *Seeds* generally 2 or 3, arillate, suspended, with fleshy albumen.

Distribution, &c.—Natives of woody places in tropical America. *Examples:*—There are 2 genera, namely, Lacistema, and Synzy-

ganthera, which contain 6 species. Their properties and uses are unknown.

Natural Order 208. CHAILLETIACEÆ.—The Chailletia Order. — Trees or shrubs. *Leaves* alternate, entire, stipulate. *Calyx* inferior, of 5 sepals ; *æstivation* induplicate. *Stamens* 10, perigynous, in two alternate whorls, the outer petaloid, and sterile. *Ovary* superior, 2—3-celled, with twin pendulous ovules. *Fruit* dry, 1—2—3-celled. *Seeds* pendulous, exalbuminous. Many botanists regard the outer whorl of sterile stamens as petals, and place the order among the Calycifloræ, near Celastraceæ, to which it seems most nearly allied.

Distribution, &c.—Natives of tropical regions. *Examples :*— Chailletia, Stephanopodium. There are 4 genera, and 10 species.

Properties and Uses. — Unimportant.

Chailletia toxicaria is a native of Sierra Leone. The fruit is called Ratsbane, from its poisonous nature.

Natural Order 209. ULMACEÆ. — The Elm Order. — Trees or shrubs. *Leaves* alternate, scabrous, with deciduous stipules. *Flowers* perfect or unisexual, in loose clusters. *Calyx* inferior, membranous, imbricated. *Stamens* perigynous, definite. *Ovary* superior, 1—2-celled ; *styles* or *stigmas* 2. *Fruit* indehiscent, samaroid or drupaceous, 1—2-celled. *Seed* solitary, pendulous, with little or no albumen ; *cotyledons* foliaceous ; *radicle* superior.

Division of the Order, &c.— This order is divided into two sections thus : —

Sub-order 1. *Celteæ.* Ovary 1-celled. *Examples :* — Celtis, Mertensia.

Sub-order 2. *Ulmeæ.* Ovary 2-celled. *Examples :* — Planera, Ulmus.

Distribution, &c. — They are chiefly natives of the northern regions of the world. There are 9 genera, and about 60 species.

Properties and Uses. — Some are valuable timber trees. The bark and fruit of some are bitter, tonic, and astringent. A few possess aromatic properties.

Celtis.—The fruit of *C. occidentalis* has a sweetish astringent taste, and has been used in dysentery, &c. The tree is commonly known under the names of Nettle-tree and Sugar-berry. *C. orientalis* has aromatic properties.

Ulmus, Elm. — The inner bark of the *Ulmus campestris*, the common English Elm, is thought to be demulcent, tonic, diuretic, and alterative, and is used in certain cutaneous diseases. The wood of this species, as also that of the *U. montana*, the Scotch or Wych Elm, &c., is useful for certain purposes, as it is not readily acted upon by water. The inner bark of *U. fulva*, the Slippery Elm or Red Elm, a native of the United States, is much employed in that country as a demulcent for both external and internal use. When ground it forms an excellent emollient poultice, like that of Linseed meal.

Natural Order 210. URTICACEÆ. —The Nettle Order.— Herbs, shrubs, or trees, with a watery juice. *Leaves* alter-

nate, usually rough, or with stinging hairs (*fig.* 129); stipulate. *Flowers* small, unisexual (*fig.* 1005), or rarely perfect. scattered, or arranged in heads or catkins. *Calyx* inferior

Fig. 1005.

Fig. 1006.

Fig. 1005. Male flower of the Small Nettle (*Urtica urens*). *c.* Calyx. *e, e, e, e.* Stamens, with 2-celled anthers. *pr.* Rudimentary pistil.——*Fig.* 1006. Vertical section of the pistil of the above. *p.* Wall of the ovary. *s.* Stigma. *o.* Ovule.

(*fig.* 1005 *c*), lobed, persistent. *Male flower* with a few distinct stamens (*fig.* 1005), perigynous, and opposite the divisions of the calyx. *Female flower* with a superior 1-celled ovary (*fig.* 712 and 1006), with a single ascending ovule (*figs.* 712 and 1006). *Fruit* indehiscent (*fig.* 757), surrounded by the persistent calyx. *Seed* solitary (*fig.* 757), erect; *embryo* (*fig.* 757), straight, enclosed in albumen; and with a superior radicle, *r.*

Distribution, &c. — The plants of this order are more or less distributed over the world. *Examples:* — Urtica, Bœhmeria, Pilea, Parietaria. Lindley estimates this order to contain 23 genera, and 300 species.

Properties and Uses.—Chiefly remarkable for yielding valuable fibres, and for the acrid stinging juice contained in their hairs.

Urtica, Nettle.—The Nettles are well known from their stinging hairs (*fig.* 129). Some of the East Indian species, as *U. crenulata* and *urentissima*, produce very violent effects. The juice is said by Endlicher to owe its powerful effects to the presence of bicarbonate of ammonia, but this is evidently an error. Flagellation by a bunch of nettles (*Urtica dioica* or *urens*), was formerly employed in palsy, &c. Some Nettles, as *U. tuberosa*, have edible tubers. Some yield useful fibres, as *Urtica heterophylla*, Neilgherry Nettle, and *U. tenacissima*, from which Caloee Hemp or Rhea fibre, one of the strongest known fibres, is obtained. *Kimosh* and *Kimshon* of the Bible, have been translated Nettles.

Bœhmeria.—Several species yield valuable fibres, as *B. Puya* or *frutescens* (Pooah fibre), in Nepaul and Sikkim, and *B. speciosa* (Wild Rhea), a very strong fibre. The most celebrated of them all, however, is *B. nivea*, from

which the fibres are obtained that are used in the manufacture of the celebrated Chinese grass-cloth.

Parietaria officinalis, Wall Pellitory, is by many regarded as a valuable diuretic and lithontriptic.

Natural Order 211. CANNABINACEÆ. — The Hemp Order. —Rough herbs with a watery juice. *Leaves* alternate, lobed, stipulate. *Flowers* small, unisexual, diœcious. *Males* in racemes or panicles. *Calyx* scaly, imbricated. *Stamens* 5, opposite the sepals ; *filaments*, filiform. *Females* in spikes, or strobiles (*fig.* 398), each flower with 1 sepal surrounding the ovary, which is superior, and 1-celled, and contains a solitary pendulous ovule. *Fruit* indehiscent. *Seed* solitary, pendulous, without albumen ; *embryo* hooked or spirally coiled, with a superior radicle.

Distribution, &c. — Natives of the temperate parts of the northern hemisphere in Europe and Asia. *Examples :* — Cannabis, Humulus. These are the only genera, and each contains but one species.

Properties and Uses. — The plants of this order yield valuable fibres, and possess narcotic, stomachic, and tonic properties.

Cannabis sativa, the Common Hemp. — The valuable fibre called Hemp is obtained from this plant. It is principally derived from Russia. It is chiefly used for cordage, sacking, and sail-cloths. This fibre has been known for more than 2500 years. The fruits, commonly termed *hemp seed*, are oleaginous and demulcent. They are used for feeding birds. When submitted to pressure, they yield about 25 per cent. of a fixed oil, which is used as a varnish, and for other purposes. When the Hemp plant is grown in tropical countries, it varies in some important characters from the ordinary *C. sativa* of colder climates, and is by some botanists considered as a distinct variety, which is named *C. sativa* var. *indica*, Indian Hemp. The plants of this variety produce less valuable fibres, but acquire marked narcotic properties, from secreting a much larger quantity of a peculiar resin than is the case with those of colder latitudes. The herb and resin are largely employed in Asia, and some other parts of the world, for the purposes of intoxication. Various preparations are in use for the purpose, as *Gunjah*, *Bang*, *Subjee* or *Sidhee* in India, and Háshísh or Hashâsh, in Arabia : these are preparations of the herb or leaves ; while another called *Churrus* is a concrete resinous exudation from the plant. Other preparations of Hemp are, *majoon*, in use at Calcutta, *mapouchari* at Cairo, and the *dawames* of the Arabs. Indian hemp is also used for smoking. The plant is also known under the name of *Diamba* in Western Africa, where it is also employed for intoxicating purposes under the names of *maconie* and *makiah*. In the form of an extract or tincture, Indian Hemp has been employed medicinally in this country and elsewhere. Pereira calls it an exhilarant, inebriant, phantasmatic, hypnotic or soporific, and stupefacient or narcotic. As obtained in this country, however, it varies so much in activity, that its effects cannot be depended upon with certainty, and it is consequently not much in use. The resin is called *cannabin*, and is the active principle of hemp.

Humulus Lupulus, the Hop.—The aggregate fruits of this plant are known under the name of strobiles (*fig.* 398), or commonly *hops*. These fruits consist of scales, and achænia, the latter of which are surrounded by yellowish aromatic glands (*fig.* 125). These lupulinic glands are the most active parts of hops. They contain a *volatile oil*, and a bitter principle called *lupuline* or *lupulite*, to the presence of which hops owe their properties. Hops are used medicinally for their stomachic and tonic properties. They are also to some extent narcotic, especially the odorous vapours from them, hence a pillow stuffed with hops is occasionally employed to induce sleep. The chief use of hops, however, is in the manufacture of ale and beer, to which they impart a pleasant aromatic bitter flavour, and tonic, and soporific properties. They also prevent beer from rapidly becoming sour.

Natural Order 212. Moraceæ. — The Mulberry Order. — Trees or shrubs with a milky juice. *Leaves* with large stipules. *Flowers* unisexual, in heads, spikes, or catkins. *Male flowers* with a 3—4-partite calyx, (*fig.* 1007), or achlamydeous. *Stamens* 3—4, perigynous (*fig.* 1007), and opposite the segments of the calyx. *Female flowers* with 3—4—5 sepals. *Ovary* superior 1—2-celled. *Fruit* a sorosis (*fig.* 707), or syconus (*figs.* 383 and 384), *Seed* solitary, pendulous (*fig.* 1008); *embryo* hooked (*fig.* 1008), in fleshy albumen, and with a superior radicle.

Fig. 1007.

Fig. 1008.

Fig. 1007. Male flower of the Black Mulberry, (*Morus nigra*).——*Fig.* 1008. Vertical section of the ovary in the female flower of the same.

Distribution, &c.— They are natives of both hemispheres, and occur both in temperate and tropical climates. *Examples* :— Morus, Broussonetia, Maclura, Ficus, Dorstenia. From the investigations of Gasparrini, Miquel, and others, it would appear that there are about 22 genera, and nearly 200 species.

Properties and Uses.— The milky juice of some species possesses acrid and poisonous properties, while in others it is bland, and may be taken as a beverage. From the milky juice of some, caoutchouc is obtained. The inner bark of some species supplies fibres. Some possess stimulant, sudorific, tonic, and astringent properties. Many yield edible fruits, while the seeds generally of the plants of this order are wholesome.

Morus.—The fruit of *Morus nigra* is our common Mulberry. It is called a sorosis. Mulberries are employed medicinally for their refrigerant and slightly laxative properties, and also to give colour and flavour to other medicines. The Sycamine tree of the Bible is supposed to be this plant. The leaves of this species, as well as those of the *Morus alba*, White Mulberry, and others, are in common use as a food for silk-worms. The roots of both *M. nigra* and *alba* are said to be cathartic and anthelmintic.

Broussonetia papyrifera, the Paper Mulberry, is so named from its inner bark being used in China, Japan, &c., for the manufacture of a kind of paper. The Otaheitans, &c. also make a kind of cloth from it.

Maclura.—The wood of *M. tinctoria*, a native of the West Indies and South America, is of a golden-yellow colour, and is much employed in this country and elsewhere as a dyeing agent. It is known as Fustic or Old Fustic, to distinguish it from Young Fustic already noticed. (See *Rhus.*) The fruit is edible. *M. aurantiaca* supplies the fruit called Osage Orange, the juice of which is used by the native tribes in some districts of America as a yellow war paint.

Ficus.—This genus has recently been divided into a number of divisions, but we shall give the former names as well as those now proposed. *F. Carica* yields the well-known fruit named the Fig. This fruit is termed a syconus. Figs are nutritive, emollient, demulcent, and laxative, and are frequently employed in medicine. The Fig tree is the *Teenah* of the Bible. *F. elastica* (*Urostigma elasticum*, or *Macropthalma elastica* of some authors), yields an inferior kind of caoutchouc. It is a native of India. This caoutchouc is rarely used in this country. Various other species yield a similar substance. The juice of *F. toxicaria* and *Dæmona* is a very powerful poison. *F. Sycamorus*

(*Sycamorus antiquorum*), the Sycamore Fig, is said to have yielded the wood from which mummy-cases were made. Richard states that the Abyssinians eat the inner bark of *F. panifica.*

Dorstenia.—The rhizomes and roots of several species have been supposed to be antidotes to the bites of venomous reptiles; those of *D. Contrayerva* and *braziliensis* have been employed in Britain for their stimulant, tonic, and diaphoretic properties.

Fig. 1009.

Fig. 1009 Branch of the Bread-fruit Tree (*Artocarpus incisa*). *a. c.* Heads of pistillate flowers. *b.* Head of staminate flowers.

Natural Order 213. — ARTOCARPACEÆ. — The Bread-fruit Order. — Trees or shrubs with a milky juice. *Leaves* alternate (*fig.* 1009), simple, with large convolute stipules. *Flowers* unisexual, in dense heads (*fig.* 1009). *Male flowers* (*fig.* 1009, *b.*), achlamydeous, or with a 2—4-lobed, or 2—4-sepaled calyx. *Stamens* opposite the lobes of the calyx, or sepals. *Female flowers* arranged over a fleshy receptacle of varying shape (*fig.* 1009, *a*, *c*,). *Calyx* inferior, tubular, 2—4-cleft, or entire. *Ovary* superior, 1-celled. *Fruit* commonly a sorosis. *Seed* erect or pendulous, with a little or no albumen; *embryo* straight, with a superior radicle.

Distribution, &c. — Exclusively tropical plants. *Examples:* — —Brosimum, Antiaris, Cecropia, Artocarpus, Phytocrene. There are 32 genera, and about 60 species.

Properties and Uses. — The milky juice contains caoutchouc, but this is not an article of commerce. This juice is in some cases poisonous, while in others it forms a nutritious beverage. Some yield valuable timber. The fruits of some are edible, and the seeds generally of plants of this order are wholesome.

Piratinera Guianensis yields the beautiful fancy wood called Snake Wood or Letter Wood.

Brosimum (*Galactodendron*) *utile* is the celebrated Palo de Vaca, or Cow-tree of South America. It is so named from its milky juice being nutritious like milk from the cow. The fibrous bark of *B. Namagua* is used in Panama for sails, ropes, garments, &c.

Antiaris. – *A. toxicaria* is the celebrated *Antsjar* or *Upas* poison tree of Java, but most of the stories related concerning it are fabulous. The milky juice is the poisonous product. This poison owes its activity to a peculiar principle named by Pelletier and Caventou *antiarin*. *Antiaris* (*Lepurandra*) *saccidora*, a native of the East Indies, has a very tough inner bark, which is used for cordage, matting, &c. Sacks also are made from it as follows: — " A branch is cut corresponding to the length and diameter of the sack wanted. It is soaked a little, and then beaten with clubs until the liber separates from the wood.

This done, the sack formed of the bark is turned inside out, and pulled down till the wood is sawed off, with the exception of a small piece left to form the bottom of the sack." These sacks are commonly used to carry rice, &c.

Cecropia peltata is remarkable for its stems being hollow except at the nodes, hence they are used for wind instruments.

Artocarpus.—The fruit of *A. incisa* is the important bread-fruit of the Moluccas and islands of the Pacific. It supplies the place of corn to the natives of those regions. *A. integrifolia* yields the Jak or Jack-fruit; this is largely used as food in Ceylon, and some other parts of the East. The inner wood is also employed to dye the Buddhist priests robes of a yellow colour.

Phytocrene—This genus is now commonly considered to constitute a new order called *Phytocrenaceæ.* The plants are climbing shrubs natives of the East Indies, with dichlamydeous unisexual flowers, and seeds with a large quantity of albumen, which character at once distinguishes them from Artocarpaceæ. They yield a large quantity of watery juice when wounded, hence they are termed Water-vines.

Natural Order 214.—Platanaceæ.—The Plane Order.—Trees or shrubs with a watery juice. *Leaves* alternate, with deciduous sheathing stipules (*fig.* 1010). *Flowers* unisexual, monœcious, in globular (*fig.* 1010) amentiferous heads; achlamydeous. *Male flowers* with one stamen, and a 2-celled linear anther. *Female flowers* (*fig.* 1010) consisting of a 1-celled ovary, and a thick style; *ovules* 1—2, suspended. *Fruits* arranged in a compact rounded head, consisting of clavate nuts with a persistent style. *Seeds* 1—2, pendulous; *embryo* in very thin albumen, with an inferior radicle.

Fig. 1010.

Fig. 1010. Branch of the Plane Tree (*Platanus orientalis*), with amentiferous heads of female flowers.

Distribution, &c.— They are natives principally of North America and the Levant. *Platanus* is the only genus, of which there are 6 ? species.

Properties and Uses.—Of no particular importance, except from their being large handsome trees, and hence much grown in our parks and squares. The leaves resemble in form those of the Sycamore tree. The timber is sometimes used by the cabinet maker.

Natural Order 215. Stilagineæ.—The Stilago Order.—Trees or shrubs. *Leaves* al-

ternate, simple, leathery, with deciduous stipules. *Flowers* minute, unisexual, in scaly spikes. *Calyx* 2—5-partite. *Males* consisting of 2 or more stamens on an enlarged thalamus; *anthers* usually 2-lobed, with a fleshy connective, and dehiscing transversely at the apex. *Females* with a superior, 1—2-celled ovary, each with 2 suspended ovules. *Fruit* drupaceous. *Seeds* suspended, albuminous; *embryo* straight, with leafy cotyledons, and a superior radicle.

Distribution, &c.—Natives of Madagascar and the East Indies. *Examples:*—Antidesma, Stilago, Falconeria. There are 5 genera, and about 20 species.

Properties and Uses.—Unimportant. Their fruits are commonly sub-acid and edible. No injurious properties are known to exist in the plants of this order.

Natural Order 216.—CERATOPHYLLACEÆ.—The Hornwort Order.—Aquatic herbs. *Leaves* verticillate. *Flowers* minute, axillary, sessile, monœcious. *Calyx* or *involucre* inferior, 8—12-partite. *Male flower* consisting of 12—20 stamens, without filaments; *anthers* 2-celled. *Female flower* with a superior 1-celled ovary, and 1 pendulous ovule. *Fruit* nut-like, indehiscent. *Seed* exalbuminous; pendulous; *embryo* with 2 pairs of cotyledons, and a large many-leaved plumule; *radicle* inferior.

Distribution, &c.—Natives of the northern hemisphere. *Ceratophyllum* is the only genus, which includes, according to Chamisso, 6 species; but according to Schleiden, there is but one. Their properties and uses are unknown.

Natural Order 217.—CALLITRICHACEÆ.—The Starwort Order.—Small aquatic herbs. *Leaves* opposite, entire, simple. *Flowers* minute, axillary, solitary, unisexual, achlamydeous. *Male flower* of 1—2 stamens, *anthers* reniform. *Female flower* with a 4-cornered, 4-celled ovary, with 1 suspended ovule in each cell. *Fruit* indehiscent, 4-celled. *Seeds* 4, peltate, with fleshy albumen; *embryo* inverted, with a very long superior radicle.

Distribution, &c.—Natives of fresh-water pools, in Europe and North America. *Callitriche* is the only genus, and includes 6 species. Their uses are unknown.

Natural Order 218. EUPHORBIACEÆ.—The Spurgewort Order.—General Character.—Trees, shrubs, or herbs, usually with an acrid milky juice. *Leaves* alternate or opposite, simple (*figs.* 311), or rarely compound, and with or without stipules. *Flowers* unisexual, (*figs.* 511, 539, 612 and 1011), monœcious (*fig.* 1011) or diœcious, axillary or terminal, sometimes enclosed in a calyx-like involucre (*fig.* 1011, *i*), achlamydeous (*figs.* 511 and 612); or with a lobed (*figs.* 539. 627 *c*) inferior calyx, having on its inside glandular or scaly appendages (*figs.* 627, *t*, and 1011, *b*), or even evident petals (*figs.* 539, *p*, and 627 *p*), which

Fig. 1011.

Fig. 1012.

Fig. 1011. Monœcious head of flowers of a species of *Euphorbia*. *i*. Involucre, a portion of which has been removed in front. *g*, *g*. Glands on the divisions of the involucre. *b*, *b*. Scales or bracts at the base of the flowers. *fm*, *fm*. Male flowers, each consisting of a stamen supported on a pedicel, to which it is articulated. *ff*. Female flower, supported on a stalk. From Jussieu.—— *Fig*. 1012. Vertical section of a coccus of the fruit of a species of *Euphorbia*.

are either distinct or united. *Male flowers* consisting of 1 (*figs.* 511 and 1011, *fm*) or more stamens (*fig.* 539, *e*), distinct or united, and 2-celled anthers. *Female flowers* with a superior ovary (*figs.* 627 and 628), which is either elevated upon a stalk (*fig.* 1011, *ff*), or sessile upon the thalamus (*figs.* 627 and 628), 1- 2- 3- or many-celled; *styles* either absent, or corresponding in number to the cells of the ovary, entire, or divided (*figs.* 612, 627 and 628), *stigmas* equal in number to the cells of the ovary, or when the styles are divided corresponding in number to their divisions (*figs.* 612, 627 and 628); *ovules* 1 or 2 in each cell, suspended from the inner angles (*fig.* 1012). *Fruit* either dry, and its parts then separating from each other and from the axis (*figs.* 660 and 693, 2), and usually opening with elasticity, or succulent and indehiscent. *Seeds* 1 or 2 in each cell, suspended (*fig.* 1012), often arillate or carunculate; *embryo* (*fig.* 1012) in fleshy albumen, with flattened cotyledons, and a superior radicle.

Diagnosis.— Herbs, shrubs, or trees, commonly with an acrid, milky juice. Flowers unisexual, monœcious or diœcious. Calyx absent or present, and then inferior. Male flowers with 1 or more stamens, and 2-celled anthers. Female flowers with a superior ovary, 1 or more celled, with 1 or 2 suspended ovules in each cell. *Fruit* of 1, 2, 3, or many dry carpels, which separate from the axis and from each other, and open with elasticity; or fleshy and indehiscent. Seeds suspended. Embryo in fleshy albumen, with a superior radicle.

Distribution, &c.— The plants of this order are more or less distributed over the globe, and are especially abundant in Equinoctial America. *Examples:* — Euphorbia, Hura, Hippomane,

Cœlobogyne, Stillingia, Mercurialis, Jatropha, Anda, Ricinus, Rottlera, Croton, Crozophora, Xylophylla, Buxus. There are about 216 genera, and 2500 species.

Properties and Uses.—The plants of this order generally contain an acrid poisonous principle or principles, which is found more or less in all their parts. In proper doses many are used medicinally as emetics, purgatives, diuretics, and rubefacients. Some are very deadly poisons. A pure starch which is largely employed for food, may be obtained from some plants; while caoutchouc may be procured from the milky juice of others. Some are entirely devoid of any acrid or poisonous principle, and are employed medicinally, as aromatic tonics. Some have edible roots; others yield dyeing agents; and some are employed on account of their wood. The more important plants of this order are described below.

Euphorbia.—Some species of this genus have succulent stems, much resembling the Cactaceæ; but their milky juice will, in most cases, at once distinguish them. The acrid resin, called usually *gum euphorbium*, is obtained from certain undetermined species. *E. canariensis*, *E. officinarum*, and perhaps *E. tetragona*, appear to be the principal sources. This drug is a dangerous acrid emetic, cathartic, and rubefacient. The seeds of *E. Lathyris*, Caper Spurge, are purgative, and yield by expression a very active cathartic oil. They were formerly called *Semina Cataputiæ minoris*. This plant is called the Caper Spurge, from the use of its pickled fruits by some housekeepers as a substitute for ordinary capers. The use of such a substitute is certainly not free from danger, although the process of pickling would seem, in a great measure, to destroy the acrid purgative nature which the fruit possesses in a fresh state. The root of *E. Ipecacuanha* is commonly known as American Ipecacuanha, from its use in the United States as an emetic. The root of *E. corollata*, called in the United States, Milk-weed, has similar properties. *E. Petitiana* and *E. Schimperiana* have very purgative properties, and are said to be sometimes mixed with Kousso (*Brayera*) to increase their activity.

Hippomane Mancinella is the famous Manchineel tree. The juice is a virulent poison. It would seem probable, that the poisonous principle of this plant is volatile, as it has been asserted, that some persons have died from simply sleeping under it. Seemann states, that if sea-water be applied to the eyes when affected by the poison, it allays the inflammation in an effectual manner.

Stillingia sebifera is called the Chinese Tallow Tree, from its seeds being covered by a white sebaceous substance, which, when separated, is found to be a pure vegetable tallow; it is used for candles, &c. *Stillingia sylvatica*, Queen's-root, is used in the United States as an emetic, cathartic, and alterative.

Omphalea triandra.—The juice is sometimes employed in Guiana as a substitute for black ink. The seed from which the embryo has been extracted is said to be eatable.

Siphonia elastica, a native of Brazil and Guiana, is the plant from which nearly all of the India-Rubber or Caoutchouc which is used in this country, is derived.

Anda braziliensis.—The seeds yield by expression a fixed oil. Both the oil and seeds are active cathartics.

Aleurites triloba, the Candle-nut tree.—The oil obtained by expression from the seeds is called *Kukui* or *Kekune*, it is largely used in some parts of the world, and has been lately imported into London. It is used as an artist's oil, and has been recommended lately as a purgative. It resembles castor oil in its action.

Elæococca verrucosa and *vernicia.*—The seeds of these plants yield by expression valuable oils, the first in use for burning, the latter by painters.

Jatropha.—The seeds of *J. purgans* (*Curcas purgans*), and those of *J. multifidus* (*Curcas multifidus*), are called Physic Nuts. They yield by pressure fixed oils, and both the seeds and oils are drastic cathartics. The oil of *J. purgans* is commonly known as *Oil of Wild Castor Seeds* or *Jatropha oil*, and

is well adapted for burning. It is said to be employed for adulterating East Indian Croton oil. A decoction of the leaves is used by the natives of the Cape Verd Islands to excite a secretion of milk. The seeds of *J. gossypiifolia*, Bastard French Physic Nut, also possesses purgative properties.

Manihot utilissima (*Jatropha* or *Janipha Manihot*), Bitter Cassava.—Cassava Meal, which is largely employed in the making of the Cassava Bread or Cakes, in common use by the inhabitants of tropical America as food, is obtained by grating the washed roots, and then subjecting the pulp to pressure and drying it over a fire. The roots and expressed juice are virulent poisons, owing chiefly to the presence of hydrocyanic acid; but their poisonous nature is destroyed by washing and applying heat. Cassava Starch, Tapioca Meal or Brazilian Arrow-root, and Tapioca are also prepared from the roots of *Manihot utilissima*. Cassava starch is the starch deposited from the expressed juice, which is afterwards washed and dried. Tapioca is prepared by submitting Cassava Starch while moist to heat on hot plates. Tapioca is largely employed as a dietetical substance in this country and elsewhere. The sauce called Casareep in the West Indies, &c. is the juice concentrated by heat and flavoured by aromatics. *Manihot Aipi* or *Janipha Lœflingii*, Sweet Cassava, has none of the poisonous properties of the preceding plant. It is generally considered as a variety of *Manihot utilissima*. Its roots is a common article of food in the West Indies and some parts of South America. It is as mealy as a potato when boiled. Cassava meal and bread, as also Cassava Starch and Tapioca, are also prepared from the sweet cassava root.

Ricinus communis, the Castor Oil Plant, or Palma Christi.—The plant called Kikayon in the Bible, and translated Gourd, is by some considered to refer to this species. This plant and other species or varieties, are largely cultivated in the East Indies and some other parts of the world for their seeds, which are commonly called Castor Seeds. The leaves have been lately recommended as an external application, and for internal administration to promote the secretion of milk. Castor oil is obtained from the seeds, either by expression with or without the aid of heat, or by decoction, or by the aid of alcohol. The oil employed in England is obtained by expression solely. Castor seeds when taken whole are extremely acrid, and have produced death; but the oil obtained from them as above, is a mild and most efficient non-irritating laxative. This oil owes its laxative properties principally to the presence of an *acrid resin*, which is contained in both the albumen and embryo. The so-called *concentrated castor oil*, which is sold in gelatine capsules, is adulterated with croton oil, and hence may produce serious effects when given in particular cases. The *Ricinus communis* has been recently cultivated in Algeria for the purpose of feeding silkworms upon its leaves. The oil has also been used there for burning, and when deprived of its acrid principle, it is said to be useful for food.

Rottlera tinctoria.—The fruit of this plant is covered by a red powder (pubescence), which has long been employed as a dye for silk. This is commonly mixed with alum and carbonate of soda, &c., when it produces a deep, durable, beautiful orange or flame colour. The dye is known at Aden under the name of *Waras* or *Wurrus*. It is designated in the Indian bazaars, *Kamala*. The root of this plant is also reputed to be used in dyeing. Kamala is also much employed in India as an anthelmintic, and in certain cutaneous diseases. The Arabs also use it in leprosy, &c. Lately it has been brought under the notice of the medical profession in this country by Mr. Hanbury, but its employment has not hitherto been attended with much success.

Croton.—The seeds of *C. Tiglium*, and probably also those of *C. Pavana*, constitute the *croton* or *tiglium* seeds of the Materia Medica. They yield by expression an oil, called *croton oil*, which is a powerful drastic cathartic in doses of from one to three minims. It is also employed externally, as a rubefacient and counter-irritant. The seeds are used in India as purgative pills, under the name of *Jamalgata pills*. *Croton Eluteria* and *C. Cascarilla* of Bennett, natives of the Bahama Islands and Jamaica, yield the aromatic tonic bark, commonly known as *cascarilla* or *eleutheria* bark. *C. Pseudo-China* yields the *Quilled Copalche bark* of Pereira, and *C. suberosum* is probably the source from whence *Corky Copalche bark* of the same author is obtained. Copalche barks in their medicinal properties resemble cascarilla. The aromatic bark known as *Malambo bark*, is the produce of *C. Malambo*. It is a favourite medicine in Columbia in diarrhœa, and as a vermifuge, and externally in the form of an alcoholic tincture in rheumatism. In the United States it is reported to be in use for adulterating ground spices.

Crozophora tinctoria, a native of the south of France, yields by expression a green juice, which becomes purplish by the combined action of ammonia and the air. This purplish dye is known under the name of *turnsole*.

Emblica officinalis. — The acrid fruit is used as a pickle in India, and when in a dried state as an astringent.

Buxus sempervirens, the Box tree, is valuable for its timber, which is much used by wood engravers. Its leaves are purgative. *B. balearica*, the Turkey-box, also yields valuable timber.

Oldfieldia africana, yields the valuable timber known as African Oak or African Teak.

Natural Order 219. SCEPACEÆ.—The Scepa Order.— This order is closely allied to Euphorbiaceæ, from which it may be distinguished by its flowers being *amentaceous*.

Distribution, &c.—Natives of the East Indies. There are 3 genera, and 6 species. The wood of *Lepidostachys Roxburghii* is called Cocus or Kokra. It is very hard, and is chiefly employed for flutes and similar musical instruments.

Natural Order 220. EMPETRACEÆ.—The Crowberry Order. — Small heath-like evergreen shrubs. *Leaves* exstipulate. *Flowers* axillary, unisexual. *Calyx* of 4—6-persistent, imbricated, hypogynous scales, the innermost occasionally petaloid and combined. *Stamens* alternate with, and equal in number to, the inner sepals. *Ovary* superior, placed on a disk, 2—9-celled; *ovules* solitary. *Fruit* fleshy, composed of from 2—5-nuts. *Seeds* solitary in each nut, ascending; *embryo* with an inferior radicle.

Distribution, &c. — Mostly natives of Northern Europe and North America. *Examples:* — Empetrum, Corema. There are 4 genera, and 4 species.

Properties and Uses. — The leaves and fruit are generally slightly acid. The berries of *Empetrum nigrum*, the Crowberry, are eaten in the very cold parts of Europe, and are also employed in Greenland in the preparation of a fermented liquor. In Portugal, the berries of *Corema* are also used in the preparation of a beverage which is said to be useful in febrile complaints.

Natural Order, 221. BATIDEÆ.— The Batis Order.— This supposed distinct order only contains a single plant, the *Batis maritima*, a succulent shrubby species, a native of the West Indies, where it is occasionally used as an ingredient in pickles. Lindley considers this order as very nearly allied to Empetraceæ, and believes that it will be ultimately placed in it.

Natural Order 222. NEPENTHACEÆ. — The Pitcher-plant Order. — Herbaceous or somewhat shrubby plants. *Leaves* alternate, and terminated by a pitcher which is provided with an articulated lamina (*fig.* 367). *Flowers* terminal, racemose, diœcious. *Calyx* inferior, with 4-divisions. *Stamens* collected into a column; *anthers* 2-celled, extrorse, usually 16. *Ovary* superior, 4-angled, 4-celled. *Fruit* capsular, 4-celled, with loculicidal dehiscence. *Seeds* very minute, numerous, albuminous; *embryo* with an inferior radicle.

Distribution, &c.—Natives of swampy ground in China and the East Indies. *Examples:— Nepenthes* is the only genus; it includes about 14 species. Their properties are unknown.

Fig. 1013. *Fig.* 1014.

Fig. 1015.

Fig. 1013. Vertical section of the flower of the common Birthwort (*Aristolochia Clematitis*).——*Fig.* 1014. The pistil and stamens of the above.——*Fig.* 1015. Transverse section of the seed.

Natural Order 223. ARISTOLOCHIACEÆ.—The Birthwort Order (*figs.* 1013—1015).—Herbs or shrubby climbers. *Leaves* alternate. *Flowers* axillary, perfect (*fig.* 1013), dull-coloured. *Calyx* tubular, superior (*fig.* 1013), with a valvate æstivation. *Stamens* 6—12, arising from the top of the ovary, and either attached to the style (*fig.* 1014), or distinct; *anthers* extrorse. *Ovary* inferior (*fig.* 1013), 3—6-celled; *style* simple; *stigmas* radiating (*fig.* 1014), and corresponding in number to the cells of the ovary. *Fruit* capsular or succulent, 3—6-celled. *Seeds* numerous (*fig.* 1013), albuminous (*fig.* 1015); *embryo* very minute (*fig.* 1015).

Distribution, &c.—Sparingly distributed in several parts of the world, but very common in tropical South America. *Examples:—* Asarum, Aristolochia. There are 9 genera, and 130 species.

Properties and Uses.—Birthworts contain a bitter principle and volatile oil; they possess generally, tonic, stimulant, and acrid properties.

Asarum.—A. europæum, Asarabacca, possesses acrid properties. It has been employed in medicine as an emetic, and as an *errhine* in headache and ophthalmia. Its powder is supposed to constitute the chief ingredient in *cephalic snuff.*

Asarum canadense Canada Snake-root or Wild Ginger, has aromatic properties. The rhizome is used in the United States as a tonic, diaphoretic, and aromatic stimulant.

Aristolochia. Birthwort. — Several species have been employed for centuries in medicine, principally on account of their supposed emmenagogue properties, and hence the name of Birthwort which is applied to the genus. The roots of *A. longa, A. rotunda, A. Clematitis, &c.*, have been thus employed. They all possess stimulant and tonic properties. The powdered root of *A. longa* is one of the ingredients in the *Duke of Portland's powder for gout.* Some of the species have been reputed specifics for snake-bites, but without any satisfactory proof. *A. anguicida* is supposed by Lindley to be the celebrated Guaco of the Columbians. The juice of its root, as well as that of many other species, is said so to stupify snakes that they may be handled and played with. The rhizome and root fibres of *Aristolochia Serpentaria*, Virginian Snake-root, are officinal. Serpentary was originally introduced as an antidote to snake-bites, but it has no efficacy in such cases. It is a valuable stimulant, tonic, and diaphoretic, and especially useful in fevers of a low or typhoid character. The roots of *A. reticulata, A. tomentosa, A. hastata*, and other species, are said to be mixed in commerce with those of *A. Serpentaria.*

Natural Order 224. SANTALACEÆ. — The Sandal-wood Order. — Herbs, shrubs, or trees. *Leaves* entire, alternate. *Flowers* usually perfect. *Calyx* superior, 4—5-cleft, valvate in æstivation. *Stamens* perigynous, equal in number to, and opposite the segments of, the calyx. *Ovary* 1-celled, inferior; *ovules* 1—4, usually suspended; *placentation* free-central. *Fruit* indehiscent, 1-seeded. *Seed* with a quantity of fleshy albumen; *embryo* straight, minute; *radicle* superior.

Distribution, &c. — Natives of various parts of the world. The species found in North America and Europe are inconspicuous herbs; those of India, Australia, &c. are trees or shrubs. The genus *Thesium* is parasitic on the roots of other plants. *Examples:* — Thesium, Fusanus, Osyris, Santalum. There are 20 genera, and about 110 species.

Properties and Uses.—Some, as *Thesium*, are slightly astringent; others have a fragrant wood; and a few produce edible fruits and oily seeds.

Fusanus acuminatus is the Quadrang Nut of Australia. The fruit is edible, and resembles Almonds in flavour.

Santalum album.—This plant is a native of India. The wood called Sandal Wood is remarkable for its fragrance. It is sometimes used as a perfume. In India it is also employed as a sedative and for its refrigerant properties. *S. Freycinatium* and *S. paniculatum* produce the sandal-wood of the Sandwich Islands.

Natural Order 225. LORANTHACEÆ. — The Mistletoe Order. — Parasitic shrubby plants. *Leaves* commonly opposite, exstipulate, greenish. *Flowers* perfect or diœcious. *Calyx* superior, with 3—8 divisions, *æstivation* valvate; sometimes absent. *Stamens* equal in number to, and opposite the lobes of, the calyx. *Ovary* inferior, 1-celled, with 1—3 ovules, erect or suspended, and a free-central placenta. *Fruit* commonly succulent, 1-celled, with a solitary seed; *embryo* in fleshy albumen, with the *radicle* remote from the hilum.

Most botanists place this order amongst Corollifloræ, and near Caprifoliaceæ, as the genus *Loranthus* has a cup-like expansion external to the floral envelopes, which is regarded by many as a true calyx, and what we have called a calyx above, as a corolla. We follow the arrangement of Lindley, who regards this cup-like body as an expansion of the pedicel. Miers again, has separated this order into two, Loranthaceæ and Viscaceæ. Loranthaceæ being usually characterised, by its large showy crimson dichlamydeous perfect flowers, long stamens, and an ovary with a solitary suspended ovule; and Viscaceæ, by its small pallid diœcious monochlamydeous flowers, with stamens sessile or nearly so, and a 1-celled ovary with 3 ovules attached to a short free-central placenta, one of which only becomes perfected.

Distribution, &c. — Principally found in the hotter parts of America and Asia. Three are natives of Europe, and a few

occur in Africa and some other regions. *Examples:* — Myzodendron, Viscum, Loranthus. There are 25 genera, and 412 species.

Properties and Uses.—Unimportant. Some are astringent.

Viscum album is the Common Mistletoe. It is parasitic on many trees, as Willows, Thorns, Lime, Elms, Oaks, Firs, and especially on Apple-trees, in this country. The Mistletoe of the Oak was an object of superstitious veneration by the Druids. The fruit has a viscid pulp, which is employed for making bird-lime. Its bark has astringent properties.

Loranthus tetrandus, a native of Chili, produces a black dye.

Natural Order 226. HELWINGIACEÆ.—This order only contains a single known species, *Helwingia ruscifolia*, which is a shrubby plant found in Japan, the leaves of which are employed as an esculent vegetable. Dr. Hooker places this genus in the order Araliaceæ, but Lindley considers it as nearly allied to Garryaceæ, from which it is chiefly known by its alternate stipulate leaves, fascicled flowers, and 3—4-celled ovary.

Natural Order 227. GARRYACEÆ. — The Garrya Order. — Shrubs. *Leaves* opposite, exstipulate. *Flowers* unisexual, amentaceous. *Male flower* with 4 sepals, and 4 stamens alternating with them. *Female flower* with a superior, 2-toothed calyx, a 1-celled ovary with 2 styles and 2 pendulous stalked ovules. *Fruit* indehiscent, baccate, 2-seeded. *Embryo* very minute, albuminous.

Distribution, &c. — Natives of the temperate parts of North America, or of the West Indies. *Examples:* — Garrya, and Fadgenia. These are the only genera; they include 6 species. They have no known properties.

Natural Order 228. JUGLANDACEÆ.—The Walnut Order (*figs.* 1016 and 1017).—Trees. *Leaves* alternate, pinnate, exstipulate. *Flowers* unisexual (*fig.* 1016). *Male flowers* in amenta (*fig.* 1016); *calyx* 2-6-partite, irregular. *Female flowers* solitary, or in small terminal clusters; *calyx* superior, regular, 3—5-lobed; *ovary* inferior, 2—4-celled at the base, 1-celled above; *ovule* solitary, erect. *Fruit* called a tryma (page 321). *Seed* (*fig.* 1017), 2—4-lobed, without albumen; *embryo* with sinuous oily cotyledons, and a short superior radicle.

Distribution, &c. — Chiefly natives of North America, but a few are found in the East Indies, Persia, and the Caucasus. *Juglans regia*, the Walnut tree, is a native of the countries between Greece and Cashmere. *Examples:* — Juglans, Carya. There are 5 genera, and 27 species.

Properties and Uses. — Chiefly important for their valuable timber, and for their oily edible seeds.

Juglans.—*J. regia*, the Walnut, is valuable for its hard, rich deep brown, beautifully marked wood. It is much employed in ornamental furniture work, and for gun stocks. The seed of this plant is our well known edible Walnut. This yields by expression a useful fixed oil of a drying nature like Linseed oil. It may be used for burning in lamps and in cookery. The bark possesses cathartic properties. *J. nigra*, the Black Walnut, a native of North America,

Fig. 1016.

Fig. 1017.

Fig. 1016. Amentum of the Walnut tree (*Juglans regia*), consisting of staminate flowers separated by scaly bracts.——*Fig.* 1017. Seed of the above.

is also esteemed for its timber. *J. alba*, the White Walnut or Butter-nut, is another useful timber tree. The inner bark of its root is used in the United States as a mild purgative. The seed is edible.

Carya.—*Carya alba* is the common Hickory, valuable for its timber, and for its edible seeds, which are commonly known as Hickory Nuts. *C. olivæformis* yields an olive-shaped or elliptical nut, which resembles the Walnut and Hickory in flavour, and is known as the Peccan Nut. *C. porcina* yields an edible nut termed the Hog Nut.

Natural Order 229. CORYLACEÆ or CUPULIFERÆ.—The Oak or Mastwort Order (*figs.* 1018—1020).—Trees or shrubs. *Leaves* (*fig.* 191) alternate, usually feather-veined, simple, with deciduous stipules. *Flowers* monœcious. *Male flowers* (*fig.* 1018), clustered, or in amenta (*fig.* 374); *stamens* 5—20 (*fig.* 1018), inserted into the base of a membranous valvate calyx, or of scales. *Female flowers* (*fig.* 1019) solitary or clustered, and

Fig. 1018. *Fig.* 1019. *Fig.* 1020.

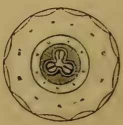


Fig. 1018. Male flower of a species of Oak (*Quercus*).——*Fig.* 1019. Female flower of the same.——*Fig.* 1020. Transverse section of the latter.

surrounded by an involucre of bracts (*fig.* 1019), which ultimately form a cupule (*figs.* 377 and 378) round the ovary and

fruit; *ovary* inferior, surmounted by a rudimentary calyx (*fig.* 1019); 3 (*fig.* 1020) or more celled; *ovules* 2 (*fig.* 1020) in each cell, or solitary, pendulous or peltate; *stigmas* almost sessile. *Fruit* a glans or nut (*figs.* 377 and 378). *Seeds* 1 or 2, without albumen.

Distribution, &c. — They abound in the forests of temperate regions. A few occur in the high lands of tropical and hot climates. *Examples:* — Carpinus, Corylus, Fagus, Castanea, Quercus, Synædrys. There are 10 genera, and about 280 species.

Properties and Uses. — Most important from their valuable timber. Many yield edible seeds, and some have highly astringent barks and cupules.

Carpinus Betulus, the Horn-beam, and *C. americanus*, are well known for their timber, which is principally employed for making agricultural implements, and for the cogs of mill wheels.

Ostrya virginica possesses a very hard wood, which in America has been called in consequence Iron-wood.

Fagus.—*F. sylvatica*, the Common Beech, is well known for its timber. The fruits (Beech-mast) form a food for pigs. The fruit of *F. ferruginea* is eaten in North America. The seeds of some species yield by expression a fixed oil.

Castanea. — *C. vulgaris* or *vesca* is the Spanish Chestnut, which is much cultivated for its timber, and for its nuts which are well known for their edible properties. They are principally imported from Spain, where they are largely employed as an article of food by the agricultural classes. *C. americana*, a native of the United States, also yields a much smaller, but very sweet kind of Chestnut, which has been occasionally imported.

Corylus Avellana, the common Hazel, is the origin of the most anciently used and most extensively consumed of all our edible nuts. There are several varieties of the Hazel, as the White, Red, and Jerusalem Filberts, the Great, and Clustered Cobs, the Red Smyrna, the Black Spanish, and the Barcelona nuts, &c. The importation alone into this country is, on an average, 150,000 bushels a year. The oil which is obtained from them by expression is occasionally employed by artists and watchmakers. Good charcoal is also obtained from the branches of the Hazel.

Quercus.—The timber of several species of this genus is extensively employed for ship-building, and for other important purposes, as that of the *Q. Robur*, the common British Oak, of which there are two varieties, which by some are regarded as distinct species, called *Q. pedunculata* and *Q. sessiflora;* the *Q. Cerris*, or Turkey or Adriatic Oak; the *Q. alba*, or White Oak; the *Q. rubra*, Red Oak; the Black Oak (*Q. tinctoria*); and the Live Oak (*Q. virens*), &c. The bark of several species is astringent, and largely employed in tanning, &c. That of *Quercus pedunculata* is most esteemed. It is also employed in medicine as an astringent and tonic. The outer bark of *Quercus Suber*, the Cork Oak, constitutes the cork of commerce. The bark obtained from the younger branches of the same tree is imported into this country from Spain. It is usually known as European Alcornoque Bark, and is employed for tanning purposes. (See *Bowdichia*, p. 529.) The inner bark of older stems is also imported as *cork-tree bark*, and similarly employed. *Quercus Ægylops.*— The acorn-cups of this species are imported from the Levant under the name of *Valonia*. The dried half-matured acorns of the same plant are also imported under the name of *Camata*, and the very young ones as *Camatina*. These three articles are very valuable for their tanning properties. *Quercus tinctoria*, or the Black Oak, has already been noticed as a valuable timber tree. Its bark is called Quercitron Bark, and is used for tanning, and in this country, its inner portion is also extensively employed for dyeing yellow. The bark of this species and that of *Quercus alba* is employed in the United States for its astringent, febrifugal, and tonic properties. *Quercus coccifera*, the Kermes Oak, has its young branches attacked by a species of *Coccus*, which forms little reddish balls upon their surface. These were formerly much used as a crimson dye. Oak trees

are especially liable to be attacked by insects, which thus produces excrescences, commonly called *galls*. The more important of which are the Nut Galls of commerce, and the large Mecca or Bussorah Galls of Pereira; which are called also *Dead-sea apples*, *mad apples*, and *apples of Sodom*. The latter are produced by *Cynips insana* on the *Quercus infectoria*. The former are also produced on the branches of the same tree by the *Cynips gallæ tinctoriæ*. They are extensively employed in tanning, for making ink, and for other purposes in the arts, &c. The best come from the Levant. Two kinds are especially known, namely *blue* and *white*. The dark coloured imperforate galls are the most valuable. The acorns of some species of *Quercus*, as *Q. Ballota*, *Q. esculenta*, and *Q. Hindsii* are edible.

Natural Order 230. MYRICACEÆ. — The Gale or Bog-Myrtle Order. —Shrubby plants, with alternate, simple, resinous-dotted leaves. *Flowers* unisexual, amentaceous. *Male flowers* achlamydeous ; *stamens* definite. *Female flowers* with a 1-celled ovary, having 1 erect ovule ; *fruit* drupaceous ; *seed* solitary, erect ; *embryo* without albumen ; *radicle* superior.

Distribution, &c. — Natives of the temperate parts of Europe and North America, and of the tropical regions of South America, India, and the Cape of Good Hope. *Examples :* — Myrica, Comptonia. There are 3 genera, and about 20 species.

Properties and Uses. — The plants of this order are chiefly remarkable for aromatic and astringent properties.

Myrica.—*M. cerifera*, the Waxberry, Candleberry, or Wax Myrtle. The bark of the root is extensively used in the United States as a stimulant astringent in diarrhœa and dysentery. The fruits when boiled yield the kind of wax known as Myrtle Wax. Other species of *Myrica* yield a somewhat similar waxy substance. The fruit of *M. sapida* is eaten in Nepaul.

Comptonia asplenifolia, Sweet Fern, is employed in the United States as an astringent and tonic in diarrhœa.

Natural Order 231. CASUARINACEÆ. — The Beefwood Order. — Trees, with pendulous, jointed, striated branches, without evident leaves. *Flowers* in bracteated spikes or heads, unisexual. *Male flowers* with 2 sepals and 2 alternating bracts, the former being united at their points ; and 1 stamen with a 2-celled anther. *Female flowers* in dense spikes or heads, naked, but each having 2 bracts ; *ovary* 1-celled, with 1—2 ascending ovules, and 2 styles. *Fruit* winged, indehiscent, collected together into a cone-shaped body. *Seed* without albumen ; radicle superior.

Distribution, &c. — They are principally natives of Australia. They are called Beef-wood trees from the colour of their timber resembling raw beef. In general appearance they resemble the branched *Equiseta*. *Examples :* — There is 1 genera, and about 32 species.

Properties and Uses. — The species of *Casuarina* yield very hard and heavy timber, and the bark of some is said to be tonic and astringent.

Casuarina.—Several species produce valuable timber, which is chiefly used in this country for inlaying and marqueterie. The wood is known under the names of Beef-wood, Botany Bay Oak, Forest Oak, He-Oak, She-Oak, &c.

Natural Order 232. BETULACEÆ.—The Birch Order.—Trees or shrubs. *Leaves* simple, alternate, with deciduous stipules.

Flowers unisexual, amentiferous, with no true calyx, but in place of that organ they have small scaly bracts, which in some cases are arranged in a whorled manner. *Male flowers* with 2 or 3 stamens opposite the bracts. *Female flowers* with a 2-celled ovary, with 1 pendulous ovule in each cell. *Fruit* dry, indehiscent, 1-celled, 1-seeded, without a cupule. *Seed* pendulous, exalbuminous ; *radicle* superior.

Distribution, &c. — They are principally natives of the colder regions in the northern hemisphere. *Examples* :—Betula, Alnus. There are 2 genera, and 65 species.

Properties and Uses. — They are valuable for their timber, and for their astringent, tonic, and febrifugal barks.

Betula. — *B. alba*, the common Birch, yields the timber known as Norway Birch. The wood is also used for charcoal. The bark yields a kind of oil, which gives the peculiar odour to Russia leather. The sap contains in the spring a good deal of sugar, hence it is used in the preparation of a wine, which is commonly known as Birch wine; this is employed in domestic practice for stone and gravel. *Betula nigra.* — The Black Birch of North America, is also valuable for its timber. Its sap like that of *B. alba* and *B. lenta*, yields sugar of good quality. *Betula papyracea* has a thick tough bark, which is used by the Indians in North America for boats, shoe-soles, and other purposes. The bark of *B. Bhajapaltra* is employed in India as a kind of paper. The bark of *B. lenta*, known in the United States as Sweet Birch or Cherry Birch, yields by distillation a volatile oil, which is identical with that of the *Gaultheria procumbens*.

Alnus glutinosa, the common Alder. — Its wood has been employed for the piles of bridges. Its bark is astringent, and has been used in medicine, and for tanning and dyeing. The leaves and catkins have similar properties. The wood is also employed for the manufacture of charcoal. The bark of *A. incana* is used in Kamschatka for making a kind of bread.

Natural Order 233. ALTINGIACEÆ or BALSAMIFLUÆ.—The Liquidambar Order. — Balsamiferous trees, with simple or lobed alternate leaves, and deciduous stipules. *Flowers* unisexual, involucrate, amentiferous. *Male flowers* naked, with numerous nearly sessile anthers. *Female flowers* with a 2-celled ovary, the whole flowers collected into a globular head ; *ovules* numerous. *Fruit* a cone-shaped body, composed of 2-celled capsules enclosed in hard scales. *Seeds* winged, peltate, albuminous ; *embryo* inverted ; *radicle* superior.

Distribution, &c. Natives of the warmer parts of India, North America, and the Levant. *Examples* :—The only genus is *Liquidambar* (*Altingia* of some botanists). It contains 3 species.

Properties and Uses. — Chiefly remarkable for fragrant balsamic properties. The species have warm bitter barks.

Liquidambar. —*L. orientale* of Miller, yields the Liquid Storax of the shops. (See *Styrax.*) This plant is called in Cyprus, *Xylon Effendi* (the wood of our Lord). The storax is obtained from the inner bark, which is afterwards used by the Turks for the purpose of fumigation. This is the *Cortex Thymiamatis* or *Storax Bark* of pharmacologists. *Liquidambar styraciflua*, a native of the United States and Central America, yields by incision, a fluid balsamic juice called *liquidambar* or *copalm balsam*. *L. altingia*, a native of Java, yields a similar fragrant balsam. In their effects and uses, both Liquid Storax and Liquidambar resemble other balsamic substances, as the Balsams of Peru and Tolu, Benzoin, &c.

Natural Order 234. SALICACEÆ.—The Willow Order (*figs.* 1021 and 1022).—Trees or shrubs. *Leaves* simple, alternate, stipulate. *Flowers* unisexual (*figs.* 1021 and 1022), amentaceous, (*figs.* 392 and 393), naked, or with a membranous or cup-like calyx. *Male flowers* (*fig.* 1021) with 1—30, distinct or monadelphous stamens. *Female flowers* with a superior, 1-celled ovary (*fig.* 1022); *ovules* numerous, erect. *Fruit* 1-celled, 2-valved. *Seeds* numerous, covered with long silky hairs (*fig.* 733), exalbuminous; *embryo* erect, with an inferior radicle.

Fig 1021. *Fig.* 1022.

Fig. 1021. Male flower of a species of willow (*Salix*), with two stamens, and a single bract at the base. *Fig.* 1022. Female flower of the above with bract at the base, and a solitary stalked ovary surmounted by two stigmas.

Distribution, &c.—Chiefly natives of cold and temperate climates. *Examples*:—Salix, Populus. There are 2 genera, and about 250 species.

Properties and Uses.—Many species are either valuable as timber, or for economic purposes. The bark commonly possesses tonic, astringent, and febrifugal properties. The hairs which invest their seeds have been employed for stuffing cushions, and for other purposes. The buds of some species secrete an oleo-resinous substance of a stimulating nature.

Salix.—Several species of this genus are used for timber, and for basket-work; also for the manufacture of charcoal. The timber is, however, wanting in strength and durability. A peculiar crystalline alkaloid resembling quina in its properties, called *salicine*, has been obtained from the bark, leaves, or flowers, of about twenty species of *Salix*. The barks of *S. Russelliana*, *S. alba*, *S. Caprea*, *S. fragilis*, *S. pentandra*, and *S. purpurea*, yield most salicine.

Populus, Poplar.—Several species of this genus have been employed for their timber. The bark of several species is tonic, astringent, and febrifugal, which properties it owes to the presence of salicine.

The three succeeding orders, namely, the Balanophoraceæ, Cytinaceæ, and Rafflesiaceæ, have been commonly put by botanists in a class by themselves, which they have placed between the Cryptogamia and Phanerogamia, and to which the name of Rhizogens or Rhizantheæ has been commonly given. The special characteristics of this class were said to be, the acotyledonous embryo, the fungoid texture, and the peculiar parasitic habit of such plants: but as one or more of such characters occur in several orders of Dicotyledones, there does not appear to be any sufficiently valid reasons for separating them from that class of plants. By Dr. Hooker, the

Balanophoraceæ have been most intimately examined, and he has arrived at the opinion that they are allied to the Haloragaceæ. We place them here, not because we believe them to have any especial relation to the orders just treated of, but simply, as their position in the Natural System has not been distinctly defined, they may be well treated of at the end of the Angiospermous Dicotyledons, to which division of the vegetable kingdom they evidently belong.

Natural Order 235. BALANOPHORACEÆ.—The Balanophora Order. — Leafless root-parasites; with amorphous fungoid stems, of various colours, but never green; and underground, more or less fleshy tubers or rhizomes. Peduncles naked or scaly, bearing spikes of flowers, which are commonly unisexual, bracteated, and of a white colour. *Male flowers* very evident, each with a tubular calyx, which is either entire, or 3—5-lobed. *Stamens* usually 3—5, sometimes 1, more or less united or distinct. *Female flowers* minute, with a tubular superior calyx, *limb* wanting, or bilabiate. *Ovary* inferior, usually 1-celled; *styles* 2; *ovule* solitary, pendulous. *Fruit* small, more or less compressed. *Seed* solitary, albuminous, with a lateral undivided or amorphous embryo.

Distribution, &c.—These plants are found parasitic on the roots of various Dicotyledonous plants, especially in the tropical and sub-tropical mountains of Asia and South America. Other species are found in different parts of Africa, Australia, &c. *Examples:* — Mystropetalon, Cynomorium, Langsdorffia, Balanophora, Helosis. There are, according to Dr. Hooker, 14 genera, and 37 species.

Properties and Uses. — Many are remarkable for their astringent properties; others are edible, as *Ombrophytum* in Peru, and *Lophophytum* in Bolivia. Others again, secrete a kind of wax.

Cynomorium coccineum is the *Fungus melitensis* of pharmacologists. It has had a great reputation as a styptic.

Langsdorffia hypogæa. — Dr. Hooker says "that this species yields so large a quantity of wax, that candles are made of it in New Granada." The stems are also said to be collected near Bogota, "and sold under the name of *Sicjos*, and used as candles on saints' days."

Natural Order 236. CYTINACEÆ.—The Cistus-rape Order. — Root parasites with a fungoid texture. *Flowers* perfect or unisexual, and either solitary and sessile, or clustered at the top of a scaly stem. *Calyx* 3—6-parted. *Anthers* sessile, opening longitudinally. *Ovary* 1-celled, inferior; *ovules* very numerous; *placentas* parietal. *Fruit* 1-celled, with numerous seeds imbedded in pulp. *Seeds* with or without albumen; *embryo* amorphous.

Distribution, &c. — Parasitic on the roots of *Cistus*, upon fleshy Euphorbiaceæ, and upon other succulent plants. They occur in the south of Europe and Africa. *Examples:* — Cytinus, Hydnora. There are 4 genera, and 7 species.

Properties and Uses.—Some have astringent properties, as *Cytinus Hypocistus.* A kind of extract is made from this in the South of Europe, and used under the name of *Succus Hypocistidis*, in diarrhœa, and for arresting hæmorrhage. *Hydnora africana* has a putrid-animal odour, but when roasted, it is eaten by the natives of Africa.

Natural Order 237. RAFFLESIACEÆ.—The Rafflesia Order.—Stemless and leafless parasites (*fig.* 239), of a fungoid texture. The plants consist solely of flowers (*fig.* 239), which are sessile upon the branches of trees, and are surrounded by scaly bracts. The flowers are perfect or diœcious. *Calyx* 5-parted (*fig.* 239), tubular; the throat surrounded by a number of thickened scaly processes, which are either distinct from each other, or united into a ring. *Anthers* 2-celled, distinct, and each opening by a pore; or united into a many-celled body and opening by a common pore. The anthers are placed upon a column (*fig.* 239), which adheres to the calyx. *Ovary* 1-celled, inferior, ovules numerous; *placentas* parietal. *Fruit* indehiscent. *Seeds* very numerous, with or without albumen; *embryo* amorphous.

Distribution &c.—Parasitic upon the stems of *Cissi* in the East Indies, and on Leguminous plants in South America. *Examples:*—Rafflesia, Brugmansia, Apodanthes. There are 5 genera, and 16 species.

Properties and Uses.—Some have styptic and astringent properties. They are chiefly remarkable for their flowers, some of which are of a gigantic size, and fungoid in texture. (See page 125).

Artificial Analysis of the Natural Orders in the Sub-class MONOCHLAMYDEÆ. Modified from Lindley.

(The Numbers refer to the Orders as previously described.)

1. Achlamydeous Flowers.

A. Leaves stipulate.
  a. Flowers unisexual.
    Ovary 1-celled.
      Ovules numerous, comose . . . . . *Salicaceæ.* 234.
      Ovules 1—2.
        Ovule erect . . . . *Myricaceæ.* 230.
        Ovule pendulous . . . . *Platanaceæ.* 214.
    Ovary 2 or more celled.
      Seeds numerous, winged . . . . . *Altingiaceæ.* 233.
      Seeds few, not winged . . . . . *Euphorbiaceæ.* 218.
  b. Flowers hermaphrodite.
    Carpel solitary.
      Ovule erect. Embryo in a vitellus . . *Piperaceæ.* 190.
      Ovule suspended. Embryo naked . . *Chloranthaceæ.* 191.
    Carpels several.
      Ovule erect. Embryo in a vitellus . . *Saururaceæ.* 192.
B. Leaves exstipulate.
  a. Flowers unisexual.
      Ovules very numerous . . . . . . *Podostemaceæ.* 193.

Ovules solitary, or very few.
Flowers naked.
Carpel single . . . . *Myricaceæ*. 230.
*Carpels double . . . . . . *Callitrichiaceæ*. 217.
Flowers in an involucre.
Anther-valves recurved . . . . . *Atherospermaceæ*. 201.
Anther-valves slit.
Embryo on the outside of the albumen *Monimiaceæ*. 202.
Embryo enclosed in the albumen . . *Euphorbiaceæ*. 218.
b. *Flowers hermaphrodite.*
Embryo in a vitellus . . . . . . *Piperaceæ*. 190.
Embryo without a vitellus . . . . *Podostemaceæ*. 193.

2. Monochlamydeous Flowers.

A. Ovary inferior, or partially so.
a. Leaves stipulate.
1. Flowers hermaphrodite . . . . . . *Aristolochiaceæ*. 223.
2. Flowers unisexual.
Fruit cupulate . . . . *Corylaceæ*. 229.
Fruit naked.
Many-seeded . . . . *Begoniaceæ*. 204.
One-seeded . . . . *Artocarpaceæ*. 213.
b. Leaves exstipulate.
1. Flowers hermaphrodite.
Ovary 3—6-celled. Ovules numerous . . *Aristolochiaceæ*. 223.
Ovary 1-celled. Ovules definite.
Ovules with a naked nucleus . . . *Loranthaceæ*. 225.
Ovules with a coated nucleus.
Calyx valvate. Embryo straight . . *Santalaceæ*. 224.
Calyx imbricated. Embryo curved . *Chenopodiaceæ*. 183.
2. Flowers unisexual.
Amentaceous.
Leaves alternate . . . . *Myricaceæ*. 230.
Leaves opposite.
Simple leaves . . . . *Garryaceæ*. 227.
Compound leaves . . . . . . *Juglandaceæ*. 228.
Not amentaceous.
Seeds numerous, parietal . . . . . *Datiscaceæ*. 205.
Seed solitary, axile . . . . . . *Helwingiaceæ*. 226.
B. Ovary superior.
a. Leaves stipulate.
1. Flowers hermaphrodite.
a. Carpels solitary.
Stipules ochreate . . . . . . *Polygonaceæ*. 180.
Stipules distinct . . . . *Petiveriaceæ*. 188.
b. Carpels more than one combined into a solid pistil.
Seeds exalbuminous.
Calyx imbricated . . . . . . *Ulmaceæ*. 209.
Calyx induplicate . . . . *Chailletiaceæ*. 208.
Seeds albuminous.
Styles or stigmas 1. Leaves usually dotted. *Samydaceæ*. 206.
Styles or stigmas 2. Leaves not dotted . *Ulmaceæ*. 209.
2. Flowers unisexual.
a. Carpels solitary.
Cells of anther perpendicular to the filament *Stilaginaceæ*. 215.
Cells of anther parallel to the filament.
Embryo straight.
Sap watery. Stipules small. Seeds albuminous . . . . *Urticaceæ*. 210.
Sap milky. Stipules large. Seeds exalbuminous . . . . *Artocarpaceæ*. 213.
Embryo hooked.
Sap watery. Seeds without albumen . *Cannabinaceæ*. 211.
Sap milky. Seeds with albumen . . *Moraceæ*. 212.

b. Carpels more than one combined into a solid pistil.
Flowers amentaceous.
Seeds arillate.
Stamen 1 . . . . *Lacistemaceæ*. 207.
Stamens more than 1 . . . . *Scepaceæ*. 219.
Seeds not arillate . . . . . . *Betulaceæ*. 232.
Flowers not amentaceous . . . . *Euphorbiaceæ*. 218.
b. Leaves exstipulate.
1. Flowers hermaphrodite.
a. Carpel solitary.
Anther-valves recurved. Leafy . . . *Lauraceæ*. 199.
Anther-valves recurved. Leafless . . *Cassythaceæ*. 200.
Anthers slit.
Leaves covered with scales . . . *Elæagnaceæ*. 196.
Leaves not scaly.
Calyx long or tubular.
Hardened at base . . . . . *Nyctaginaceæ*. 181.
Tube hardened . . . . . *Scleranthaceæ*. 185.
Not hardened at any part.
Stamens in the points of the sepals *Proteaceæ*. 197.
Stamens not in the points of the sepals . . . . *Thymelaceæ*. 194.
Calyx short, not tubular or but slightly so.
Flowers in involucels . . . *Polygonaceæ*. 180.
Flowers not in involucels.
Calyx dry and coloured . . . *Amaranthaceæ*. 182.
Calyx herbaceous or succulent.
Stamens hypogynous, or nearly so *Chenopodiaceæ*. 183.
Stamens perigynous . . . *Basellaceæ*. 184.
b. Carpels more than one, either distinct, or combined into a solid pistil.
Carpels distinct . . . . *Phytolaccaceæ*. 186.
Carpels combined.
Seeds exalbuminous.
Calyx tubular.
Ovary 2-celled . . . . . . *Aquilariaceæ*. 195.
Ovary 4-celled . . . . . . *Penæaceæ*. 198.
Calyx tubular, or imperfect . . *Podostemaceæ*. 193.
Seeds albuminous . . . . . . *Phytolaccaceæ*. 186.
2. Flowers unisexual.
a. Carpels solitary, or quite distinct.
Calyx tubular.
Anthers opening by recurved valves . *Atherospermaceæ*. 201.
Anthers opening longitudinally . . *Myristicaceæ*. 203.
Calyx not tubular.
Seeds exalbuminous. Embryo straight.
Leaves verticillate . . . . . . *Ceratophyllaceæ*. 216.
No evident leaves . . . . . . *Casuarinaceæ*. 231.
Seeds albuminous.
Embryo curled round the albumen . *Chenopodiaceæ*. 183.
Embryo straight . . . . . . *Monimiaceæ*. 202.
b. Carpels more than one, combined into a solid pistil.
Ovules indefinite.
Leaves with pitchers . . . . . . *Nepenthaceæ*. 222.
Ovules definite.
Fruit fleshy. Seeds ascending . . *Empetraceæ*. 220.
Fruit dry. Seeds suspended . . . *Euphorbiaceæ*. 218.

Artificial Analysis of the Rhizogens of Lindley.

A. Ovules solitary . . . . *Balanophoraceæ*. 235.
B. Ovules indefinite.
Anthers opening by slits . . . . . . *Cytinaceæ*. 236.
Anthers opening by pores . . . . . . *Rafflesiaceæ*. 237.

Monochlamydeous or Achlamydeous flowers also occasionally occur in the following Orders of the Sub-classes Thalamifloræ, Calycifloræ, and Corollifloræ.

1. Thalamifloræ: — *Ranunculaceæ*, *Menispermaceæ*, *Papaveraceæ*, *Flacourtiaceæ*, *Caryophyllaceæ*, *Sterculiaceæ*, *Bytlneriaceæ*, *Tiliaceæ*, *Malpighiaceæ*, *Rutaceæ*, *Xanthoxylaceæ*, and *Geraniaceæ*.

2. Calycifloræ: — *Celastraceæ*, *Rhamnaceæ*, *Anacardiaceæ*, *Leguminosæ*, *Rosaceæ*, *Lythraceæ*, *Saxifragaceæ*, *Cunoniaceæ*, *Paronychiaceæ*, *Mesembryaceæ*, *Passifloraceæ*, *Myrtaceæ*, *Onagraceæ*, *Haloragaceæ*, *Combretaceæ*, *Hamamelidaceæ*, and *Araliaceæ*.

3. Corollifloræ: — *Oleaceæ*, and *Primulaceæ*.

Class I. — *Dicotyledones.*

Division 2. Gymnospermia.

Natural Order 238. PINACEÆ or CONIFERÆ.—The Pine or Coniferous Order. — Resinous trees or evergreen shrubs, with branched continuous stems. *Leaves* needle-shaped (*fig.* 318), or lanceolate, parallel-veined, fascicled (*fig.* 265) or imbricate. *Flowers* naked, monœcious or diœcious. *Male flowers* arranged in deciduous amenta. *Stamens* 1 or several, monadelphous; *anthers* 2 or many-celled, opening longitudinally. *Female flowers* in cones (*figs.* 269, 397 and 1023), consisting of flattened imbricated carpels or scales arising from the axils of membranous bracts; *ovules* naked, 2 (*fig* 709) or more, on the upper surface of each carpel. *Fruit* a woody cone (*figs.* 269 and 1023), or a galbulus (*figs* 704 and 705). *Seeds* naked (*figs.* 1024 and 1025), with a hard crustaceous integument, albuminous, *cotyledons* 2, or many (*fig.* 750).

Fig. 1023.

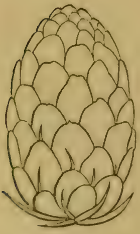


Fig. 1024.

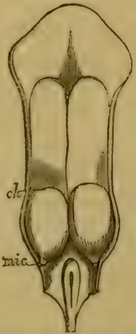


Fig. 1025.

Fig. 1023. A ripe cone of the Larch (*Abies Larix* or *Larix europæa*).——*Fig.* 1024. A ripe scale or carpel of the Scotch Fir (*Pinus sylvestris*), with two winged seeds at its base. *mic.* Micropyle. *ch.* Chalaza.——*Fig.* 1025. A scale of the Larch bearing a naked seed, the other seed has been removed.

Division of the Order, and Examples of the Genera. — This order has been divided into two sub-orders as follows: —

Sub-Order 1. *Abieteæ.* — Ovules inverted, with the micropyle next the base of the carpel (*fig.* 709). Pollen oval. *Examples:* — Pinus, Abies, Araucaria, Eutassa, Dammara.

Sub-Order 2. *Cupresseæ.* — Ovules erect. Pollen spheroidal. *Examples:* — Juniperus, Thuja, Cupressus, Wellingtonia, Taxodium.

Distribution, &c. — The plants of this order occur in various parts of the world, both in cold and tropical regions. They abound, however, most in temperate climates. There are about 30 genera, and 120 species.

Properties and Uses.—They possess very important properties. Many supply valuable timber, and most of the species contain an oleo-resinous juice or turpentine, which is composed of a volatile oil and resin.

Pinus. — Several species of this genus are valuable timber trees; as *P. sylvestris*, the Scotch Fir, which yields the timber known as Dantzic or Riga Fir, and Russian Deal; *P. Strobus*, the White Pine or Deal of the United States; *P. mitis* and *P. palustris*, the Yellow Pine or Deal; *P. rigida*, *P. Lambertiana*, &c. &c. The wood of these trees is used to an enormous extent in this country and elsewhere. *Pinus sylvestris*, the Wild Pine or Scotch Fir, is the source of Common Turpentine; this yields by distillation an essential oil, called *oil of turpentine*, or *spirits* or *essence of turpentine*, and yellow and black resin. The wood also yields by destructive distillation, *wood-tar*, and *pitch*. The inner bark of the Scotch Fir is used in Norway for making bark bread. From the leaves also of this species the substance called Pine-wool or Fir-wool is prepared. It is used for stuffing mattresses, &c. It is said to be repulsive to vermin. An oily substance called fir wool oil and fir wool spirit, has also been recently introduced into this country from Germany, and recommended for external use in rheumatism, neuralgia, &c. *P. Pinaster* of Lambert, the *P. maritima* of De Candolle, the Cluster Pine, yields Bordeaux turpentine, Galipot tar, and pitch. *P. palustris*, the Swamp Pine or Long-leaved Pine, "furnishes by far the greater proportion of turpentine, tar, &c. consumed in the United States, or sent from thence to other countries." *P. Tæda*, the Frankincense Pine, also yields turpentine. *P. Pinea*, the Stone Pine, has edible seeds, which are used as a dessert under the name of *pine-nuts*. *P. Cembra*, the Siberian Stone Pine, has also edible seeds. The young shoots by distillation yield the so-called Carpathian balsam. *P. Pumilio*, the Mugho or Mountain Pine, yields by spontaneous exudation an oleo-resin called Hungarian balsam. *Pinus Geradiana* found in Thibet and Affghanistan, yields edible seeds. *P. longifolia*, an Himalayan species, according to Royle, yields a very fine turpentine.

Abies.—Several species of this genus, like those of the former, supply valuable timber, as *Abies excelsa*, the Spruce Fir, Spruce or Dantzic Deal, *Abies alba*, the White Spruce, *A. canadensis*, the Hemlock Spruce, *A. Larix* or *Larix europæa*, the Common Larch, &c. *Abies excelsa*, Norway Spruce Fir, yields by spontaneous exudation Common Frankincense or Thus, which is used in pharmacy in the preparation of Burgundy Pitch. Good paper has been made from the wood of this species. The leaf-buds are used on the Continent in the preparation of a kind of beer and tincture which are employed in scorbutic and rheumatic complaints. *A. Balsamea*, the Canadian Balsam or Balm of Gilead Fir, yields Canada Balsam. *A. canadensis*, the Hemlock Spruce Fir, is said to exude an oleo-resin similar to Canada Balsam. *A. Picea*, the Silver Fir, yields Strasbourgh turpentine. Its leaf-buds, like those of *A. excelsa*, are employed in the preparation of a kind of beer, which is used for similar purposes. *A. nigra*, the Black Spruce Fir.—The young branches of this when boiled in water, and the solution afterwards concentrated, forms Essence of Spruce, which is employed in the preparation of Spruce Beer. *A. Larix* of

Lambert, the *Larix europæa* of De Candolle, yields Larch or Venice turpentine, and a kind of Manna, called Larch Manna or Manna de Briançon. The bark of the Larch is sometimes used in tanning.

Cedrus.—Cedrus Libani, the Cedar of Lebanon, and *C. Deodara*, the Deodar, are most valuable timber trees. The turpentine obtained from the latter is known in India, where it is in great repute, under the name of *kelon-ke-tel.*

Araucaria. — The species of this genus, known as *A. imbricata*, from Chili, and *A. Bidwillii*, from Moreton Bay, have edible seeds. Those of the former are extensively used for food by the natives of Chili and Patagonia. It is said, that "the fruit of one large tree, will maintain eighteen persons for a year."

Dammara australis, the Kawrie or Cowdie Pine of New Zealand, produces a timber which is much valued for making masts and spars. A gum-resin known under the names of Australian Copal, Kawrie Gum, and Australian Dammar, is now largely imported into this country, where it is chiefly used in the preparation of varnishes. *D. orientalis* yields a somewhat similar gum-resin, known as Indian Dammar.

Juniperus. — *J. communis*, the common Juniper. The fruit, and the volatile oil obtained from it and other parts of the plant, have stimulant and diuretic properties. Juniper is used to flavour English gin and Hollands. Turpentine is, however, frequently employed for the former, on account of its comparative cheapness. Juniper wood has a reddish colour, and is used occasionally for veneers. *J. Oxycedrus.*—In France they obtain from the wood of this plant by dry distillation, a tarry oil called Huile de Cade. It is principally used in veterinary medicine. Its wood is very durable. *J. bermudiana* is the Red or Pencil Cedar, and *J. virginiana*, the Virginian Red Cedar. The wood of these is used for Cedar pencils ; that of the former is considered the best. *J. Sabina* the common Savin. — The young branches, and the oil obtained from them, have acrid, stimulant, diuretic, and emmenagogue properties. In large doses they are irritant poisons, and have been frequently taken to cause abortion.

Cupressus, the Cypress.— The wood of some species is very durable. Some suppose that the Gopher-wood of the Bible was obtained from species of *Cupressus* and other Coniferæ.

Callitris quadrivalvis, the Arar Tree, yields the resin called Sandarach, Juniper-resin, or Gum Juniper. It is imported from Magadore, and employed in the preparation of varnishes. When powdered it is called *pounce*. Its wood is very durable, and is used by the Turks for the floors and ceilings of their mosques.

Natural Order 239. Taxaceæ. — The Yew Order (*figs.* 1026, 1027). — Trees or shrubs, with continuous branches. *Leaves* usually narrow, rigid, and veinless ; sometimes broad, with forked veins. *Flowers* unisexual, naked, bracteated. *Male flowers* several together, each with one or several stamens, which are united (*fig.* 1026) or distinct ; *anthers* bursting longitudinally. *Female flowers* solitary, and consisting of a single naked ovule, which is either terminal, or placed in the axil of a bract. *Seed* small, enveloped in a cup-shaped, fleshy mass (*figs.* 706 and 1027, *ar*), which Dr. Hooker states is formed from the outer

Fig. 1026.

Fig. 1027.

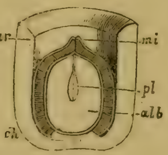


Fig. 1026. Male flower of the Common Yew (*Taxus baccata*), with numerous monadelphous stamens.——*Fig.* 1027. Vertical section of the fruit of the same. *ar.* The succulent cup-shaped mass surrounding the solitary seed. *pl.* Embryo. *alb.* Albumen. *ch.* Chalaza. *mi.* Micropyle.

coat or primine of the ovule, albuminous (*fig.* 1027, *alb*); *embryo* straight (*fig.* 1027, *pl*).

Distribution, &c. — Natives of the mountains of tropical countries, and of temperate regions. *Examples*:—Taxus, Dacrydium, Salisburia. There are 9 genera, and 50 species.

Properties and Uses. — In their general properties they resemble the Coniferæ.

Taxus baccata, the Common Yew, produces extremely durable and valuable timber. Its leaves and young branches act as narcotico-acrid poisons, both to the human subject and other animals. It is said that animals may feed upon the young growing shoots with impunity, but that when these have been cut off, and left upon the ground for a short time, they are then poisonous. This notion is altogether erroneous, for the shoots are poisonous in all conditions. We believe that the pulp surrounding the seed is harmless, but that the seed itself is poisonous. Yew leaves and berries have been given medicinally for their emmenagogue, sedative, and antispasmodic, &c. effects.

Podocarpus Totarra, and some other New Zealand species, are valuable timber trees.

Dacrydium Franklinii, the Huon Pine of Australia.—The wood is valuable for ship-building. Other species as *D. taxifolium*, the Kakaterro of New Zealand, and *D. cupressinum*, the Dimon Pine, are also valuable timber trees.

Natural Order 240. Gnetaceæ. — The Jointed Fir Order.— Small trees or shrubs, with jointed stems and branches. *Leaves* opposite, entire, net-veined, sometimes small and scale-like. *Flowers* unisexual, in catkins or heads. *Male flowers* with a 1-leaved calyx; *anthers* 1-celled, with porous dehiscence. *Female flower* naked, or surrounded by 1 or 2 scales; *ovules* 1—2 naked, pointed by a style-like process. *Seed* succulent; *embryo* dicotyledonous, in the axis of fleshy albumen. Agardh has recently expressed a belief that, the Gnetaceæ are more nearly allied to Loranthaceæ than to Coniferæ. Henfrey inclined to the same opinion.

Distribution, &c. — The plants of this order occur in both tropical and temperate regions. There are 2 genera,—Ephedra and Gnetum, and, according to Endlicher, 28 species.

Properties and Uses. — Unimportant. The seeds and leaves of some species are eaten. Some are reputed astringent.

Natural Order 241. Cycadaceæ.— The Cycas Order. — Small palm-like unbranched trees or shrubs, or occasionally dichotomous, with their surface marked by the scars of fallen leaves. *Leaves* clustered at the summit, pinnate, parallel-veined, hard and woody, and usually circinate in vernation. *Flowers* quite naked, unisexual, diœcious. *Male flowers* in cones, consisting of scales, from the under surface of which 1-celled anthers arise. *Female flowers* consisting of naked ovules placed on the margins of altered leaves, or of ovules arising from the base of flat scales or from the under surface of peltate ones. *Seeds* hard or succulent, with 1 or several embryos contained in fleshy or mealy albumen.

Distribution, &c. — Natives principally of the temperate and tropical parts of America and Asia; and occasionally at the

Cape of Good Hope, Madagascar, and Australia. *Examples:*— Cycas, Dion, Zamia, Encephalartos. There are 7 genera, and 46 species.

Properties and Uses. — The stems and seeds of the plants of this order yield mucilage and starch.

Cycas.—From the stems of *Cycas circinalis* and *C. revoluta*, a starch may be obtained. Of this a kind of sago is prepared; that from *C. revoluta* is said to constitute Japan Sago. This sago is not an article of European commerce, all the sago imported into Europe being derived from species of Palms. (See Sagus and Saguerus.) Japan sago and other kinds are much esteemed as articles of food. The seeds of the above species are also edible.

Dion edule has large mealy seeds from which the Mexicans prepare a kind of arrow-root.

Zamia.—In the Bahamas and other West Indian Islands, excellent arrowroot is prepared from the starch obtained from the stems of *Z. integrifolia* and other species. It is sold in the West India markets, but is not known as a commercial article in this country or in any other part of Europe.

Encephalartos.—Various species contain starch, and form what is called Caffre-bread.

Artificial Analysis of the Natural Orders of the GYMNOSPERMIA.

Class I. *Dicotyledones.*

Division 2. Gymnospermia.

1. *Stem jointed, branched.*	
Anthers 1-celled with porous dehiscence . .	*Gnetaceæ.* 240.
2. *Stem not jointed.*	
Branched. Leaves simple.	
Seeds in cones	*Coniferæ.* 238.
Seeds solitary	*Taxaceæ.* 239.
Not branched. Leaves pinnate	*Cycadaceæ.* 241.

CLASS II. MONOCOTYLEDONES.

Sub-class I. *Dictyogenæ.*

Natural Order 242. DIOSCOREACEÆ. — The Yam Order. — Shrubby plants, with twining stems rising from tuberous root-stocks or tubers placed above or under the ground. *Leaves* net-veined, stalked. *Flowers* unisexual, diœcious, small, bracteated, arranged in a spiked manner. *Male flower:—Perianth* 6-cleft. *Stamens* 6, inserted at the base of the perianth. *Female flower:—Perianth* superior, 6-parted. *Ovary* inferior, 3-celled; *styles* 3, distinct, or 1 and deeply trifid; *ovules* 1—2 in each cell, suspended. *Fruit* dehiscent and compressed, or fleshy, 1—3-celled. *Seeds* albuminous; *embryo* small, in a cavity in the albumen.

Distribution, &c. — Chiefly tropical plants. *Tamus communis* is, however, found in Britain and other temperate regions. *Examples:* — Tamus, Testudinaria, Dioscorea. There are 7 genera, and 150 species.

Properties and Uses. — The plants generally contain an acrid

principle. The tuberous root-stocks of many species of *Dioscorea* are used for food in tropical countries.

Tamus communis, Common Black Bryony, has a large fleshy root possessing when fresh considerable acridity. It is sometimes used as a topical application to bruised parts to remove the marks. Taken internally, it acts as a diuretic, and also, it is said, as an emetic and cathartic. The young shoots of this species, and those of *T. cretica*, when boiled, have been eaten like asparagus, but when used in this way, care must be taken to have them thoroughly boiled to get rid of their acridity.

Dioscorea.—The tuberous root-stocks of several species, as those of *D. alata*, *D. sativa*, and *D. aculeata*, when boiled, are eaten in tropical countries, as potatoes are in Europe. The Chinese Yam is now cultivated in this country, and when properly boiled, is much esteemed by many as an esculent. Some species of *Dioscorea* are very acrid even when boiled, and cannot therefore be used for food.

Testudinaria elephantipes, a native of the Cape of Good Hope, has a very peculiar tuberous stem, hence it has been called Elephant's foot or Tortoise plant. The inner part of this above ground tuber is very mealy, and is used for food by the Hottentots.

Natural Order 243. SMILACEÆ—The Sarsaparilla Order.—Herbs or shrubs, more or less climbing (*fig.* 1028). *Leaves*

Fig. 1028.

Fig. 1028. A portion of a branch, with leaves and fruit of *Smilax papyracea.*

petiolate (*fig.* 1028), net-veined, articulated. *Flowers* regular, unisexual and diœcious, or hermaphrodite. *Perianth* inferior, 6-parted, with all its divisions alike. *Stamens* 6, perigynous or rarely hypogynous; *anthers* introrse. *Ovary* superior, 3-celled; *stigmas* 3. *Fruit* a berry (*fig.* 1028), few or many-seeded. *Seeds* with a minute embryo, albuminous.

Distribution, &c.—The species are scattered over various parts of the world, both in tropical and temperate climates. They are, however, most abundant in tropical America. *Examples:*—Smilax, Ripogonum. There are 4 genera, and about 120 species, according to Lindley. Other botanists make the number of species considerably more.

Properties and Uses. — The species generally possess alterative properties.

Smilax.—The roots of several species or varieties of *Smilax*, constitute the Sarsaparilla of the materia medica, which is commonly regarded, and as we believe most justly so, as an alterative in venereal and skin diseases, in rheumatism, &c. Upwards of 130,000 lbs. are annually used in this country alone. Several kinds of Sarsaparilla are known, of which the most esteemed is that which is called Jamaica Sarsaparilla, although it is not the produce of that island, but of Central America and the northern parts of South America. It is obtained from *S officinalis.* Other kinds of Sarsaparilla distinguished in commerce, are Lima, probably from *S. officinalis;* Lean Vera Cruz, from *S. medica;* Lisbon or Brazilian, from *S. papyracea*, and probably also, from *S. officinalis ; Guatemala*, from *S. papyracea;* Honduras, from I believe, *S. papyracea:* and Caracas or Gouty Vera Cruz, probably from *S. officinalis* and *S. syphilitica.* Several other species of *Smilax* are in use in different parts of the world, as *S. aspera* in the south of Europe. Its roots form Italian Sarsaparilla. *S. China*, is commonly regarded as the source of the China root of the shops. Several spurious China roots are in use in America; their source is doubtful.

Ripogonum parviflorum possesses similar properties to Sarsaparilla. It is a native of New Zealand, where it is much used as a curative agent.

Natural Order 244. Trilliaceæ. — The Trillium or Paris Order. — Unbranched herbaceous plants, with rhizomes, or tuberous root-stocks. *Leaves* whorled, not articulated, net-veined. *Flowers* large, terminal, solitary, hermaphrodite. *Perianth* inferior, with 6 — 8 parts, arranged in 2 rows; the parts being all alike, or those forming the inner row much larger and coloured. *Stamens* 6 — 10, with linear apicilar anthers. *Ovary* superior, 3—5-celled, with a corresponding number of styles and stigmas; *placentas* axile. *Fruit* succulent, 3—5-celled. *Seeds* numerous, albuminous ; *embryo* minute.

Distribution, &c.—Natives of the temperate regions of Europe, Asia, and America. *Examples* :—Paris, Trillium. There are 4 genera, and 30 species.

Properties and Uses. — The plants of this order are reputed narcotic, acrid, emetic, or purgative, but none are employed in regular practice.

Natural Order 245. Roxburghiaceæ. — The Roxburghia Order. — Twining shrubs, with tuberous roots. *Leaves* net-veined, leathery, broad. *Flowers* large and showy, solitary, hermaphrodite. *Perianth* inferior, with 4 petaloid divisions. *Stamens* 4, hypogynous ; *anthers* introrse, apicilar. *Ovary* superior, 1-celled, with a basal placenta ; *stigma* sessile, *Fruit* 2-valved, 1-celled. *Seeds* numerous, in 2 stalked clusters, anatropous ; *embryo* in the axis of fleshy albumen.

Distribution, &c.—They are natives of the hotter parts of the East Indies. There is but one genus, Roxburghia, and 4 species. Their properties are unimportant.

Natural Order 246. Philesiaceæ. — The Philesia Order. — *Diagnosis.* — The plants of this order are closely allied to the Roxburghiaceæ, from which however, they are readily distinguished by their hexamerous perianth and andrœcium, perigy-

nous stamens, parietal placentation, long style, and semi-anatropous ovules.

Distribution, &c.— Natives of Chili. There are 2 genera,— Philesia and Lapageria, and 2 species. In their properties they are said to resemble Sarsaparilla.

Sub-class II. *Petaloideæ or Floridæ.*

1. Epigynæ.

Natural Order 247. ORCHIDACEÆ.—The Orchis Order (*figs.* 1029—1032).—General Character.—Herbs or shrubs, terres-

Fig. 1029.

Fig. 1030.

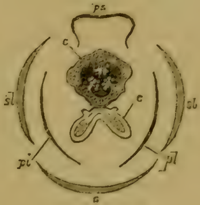


Fig. 1031.

Fig. 1032.

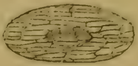


Fig. 1029. Front view of the flower of the Tway-blade (*Listera ovata*), showing the bifid labellum with the other five divisions of the perianth; and the essential organs of reproduction forming a column.——*Fig.* 1030. Diagram of the flower of an Orchid. *s*, *sl*, *sl*. The three outer divisions of the perianth; *s* being anterior or inferior, *sl*, *sl* being lateral. *pl*, *pi*. The two lateral divisions of the inner whorl of the perianth. *ps*. The superior division (*Labellum*) of the inner whorl; this by the twisting of the ovary becomes ultimately anterior. *c*. The fertile stamen, with two anther lobes. *c*. Transverse section of the ovary, with three parietal placentas.——*Fig.* 1031. Fruit of an Orchid, dehiscing by three valves, each bearing a placenta and numerous seeds.——*Fig.* 1032. Seed of an Orchid, with a loose reticulated testa.

trial (*figs.* 242 and 243) or epiphytical (*fig.* 237). *Roots* fibrous (*fig.* 237) or tuberculated (*figs.* 242 and 243); no true stem, or a pseudo-bulb (*fig.* 237). *Leaves* entire (*fig.* 296), generally sheathing. *Flowers* irregular (*figs.* 534 and 1029), solitary or numerous, with a single bract, hermaphrodite. *Perianth* superior (*figs.* 534 and 1029), usually petaloid, and composed of six pieces (*fig.* 1030), which are commonly arranged in two whorls; the *outer whorl*, *s*, *sl*, *sl*, formed of three pieces (*sepals*),

more or less united below or distinct, one, *s*, being anterior, or when the ovary is twisted posterior (*figs.* 534 and 1029), and two, *sl*, *sl*, lateral; the *inner whorl* (*fig.* 1030, *pi*, *pl*, *ps*) usually of three pieces (*petals*), or rarely of but one, alternating with the pieces in the outer whorl; one (the *labellum* or *lip*) (*fig.* 1030, *ps*) posterior, or by the twisting of the ovary anterior, (*fig.* 1029), usually longer and larger than the other pieces, and altogether different to them in form (*fig.* 1029), often spurred (*fig.* 534); sometimes the labellum exhibits a division into 3 regions, of which the lowest is termed the *hypochilium*, the middle the *mesochilium*, and the upper the epichilium. *Stamens* and *style* united together (gynandrous) (*figs.* 534, 552 and 1029) in a central column or *gynostemium*. The *column* usually bearing 1 perfect anther and two lateral abortive anthers, or rarely two lateral perfect anthers and one abortive anther in the centre. *Pollen* powdery, or more or less collected into grains, or in waxy or mealy masses (*pollinia*) (*fig.* 550, *p*); the masses free or attached by their stalk, *c* (caudicle), to the apex (*rostellum*) of the stigma (*fig.* 552). *Ovary* inferior, 1-celled, with 3 parietal placentas (*figs.* 607 and 1030), bearing a number of anatropous ovules; *style* united with the filaments and together forming the gynostemium (*figs.* 534 and 1029); *stigma* a viscid space in front of the column (*fig.* 552). *Fruit* usually capsular, 3-valved (*fig.* 1031); the valves bear the placentas in their middle, and separate from the central parts or midribs of the component carpels, which are left as an open frame-work; the fruit is rarely fleshy, and indehiscent. *Seeds* very minute and numerous (*fig.* 1031), with a loose netted (*fig.* 1032), or rarely hard crustaceous testa, exalbuminous; *embryo* a fleshy solid mass.

Diagnosis.—This order is known by its irregular flowers; by the peculiar form which the labellum assumes in many cases, so as to cause the flower to resemble some insect, reptile, bird, or other living object; by its gynandrous stamens; by its cohering pollen; and by its 1-celled inferior ovary with 3 parietal placentas.

Distribution, &c. — They are more or less abundantly distributed in nearly every region of the globe, except in those which have a very cold or dry climate. Some species are terrestrial and occur chiefly in temperate regions; others are epiphytal and are confined to hot climates. *Examples:* — Pleurothallis, Malaxis, Dendrobium, Corallorrhiza, Epidendrum, Cattleya, Phaius, Vanda, Aërides, Oncidium Stanhopea, Calanthe, Orchis, Satyrium, Habenaria Vanilla, Listera, Spiranthes, Goodyera, Cypripedium. According to Lindley, our standard authority on this remarkable order of plants, there are about 460 genera, and 3000 species.

Properties and Uses.—The plants of this order, which present so much interest to the horticulturist from the singularity, beauty,

and fragrance of their flowers, are of little importance in an economical or medicinal point of view. Some are aromatic and fragrant, others possess nutritious roots, and some produce a colouring matter like indigo.

Vanilla planifolia, *V. aromatica*, *V. guianensis*, *V. palmarum*, *V. pompona*, and other species, are remarkable for their fragrant odoriferous fruit, which constitutes the Vanilla or Vanile of the shops. Vanilla is extensively used in flavouring chocolate, and also in confectionary, and in perfumery. It has been also employed on the Continent as a medicinal agent, in hysteria, &c. The fruits of *V. planifolia* and *V. aromatica* are commonly regarded as the most fragrant.

Sobralia.—The fruit of a species of *Sobralia* is said to yield in Panama a kind of Vanilla which is called *chica*.

Angræcum fragrans —The dried leaves of this fragrant species are used as a kind of tea in the Mauritius. This is commonly known as *Faham* or *Bourbon tea*.

Eulophia vera and *E. campestris.*— The tubercular roots of these species are used in India in the preparation of the nutritious substance known by the names of Salep, Salop, and Saloop.

Orchis.—The root of several species of this genus, as those of *O. mascula*, *O. latifolia*, *O. morio*, *&c.*, when dried, form European or Indigenous Salep. That prepared from *O. mascula* is said to be the best. Salep contains *bassorine* and a little starch, and possesses similar properties to those of other starches and mucilaginous substances.

Natural Order 248. Apostasiaceæ. — The Apostasia Order.— Herbs, with regular hermaphrodite flowers. *Perianth* superior, regular, with 6 divisions. *Stamens* 2 or 3, united by their filaments with the lower part of the style into a column ; *anthers* sessile upon the column, 2 or 3. *Ovary* inferior, 3-celled, with axile placentation ; ovules numerous ; *style* united below to the filaments into a column, but prolonged above into a filiform process. *Capsule* 3-celled, 3-valved. Seeds very numerous.

Distribution, &c. — Natives of damp woods in tropical India. *Examples* :—Apostasia, Neuwiedia. There are 3 genera, and 5 species. Their properties are altogether unknown.

Natural Order 249. Burmanniaceæ. — The Burmannia Order. — Herbaceous plants, without true leaves, or with tufted radical ones. *Flowers* hermaphrodite, regular. *Perianth* tubular, regular, superior, usually with 6 divisions. *Stamens* inserted into the tube of the calyx, 3 or 6, distinct. *Ovary* inferior, 1-celled with 3 parietal placentas, or 3-celled with axile placentas. *Capsule* 1—3-celled. *Seeds* numerous, very minute; *embryo* solid.

Distribution, &c. — They are principally found in the tropical parts of Asia, Africa and America. *Examples* : — Burmannia, Apteria, Thismia. According to Miers, there are 10 genera, and 38 species. They have no important properties.

Natural Order 250. Zingiberaceæ. — The Ginger Order. —Aromatic herbaceous plants, with a creeping rhizome, and broad, simple, stalked, sheathing leaves, with parallel veins springing from the mid-rib. *Flowers* arranged in a spiked or racemose manner, and arising from spathaceous bracts. *Perianth*

superior, irregular, arranged in 3 whorls, each whorl composed of 3 pieces. *Stamens* 3, distinct, 2 lateral abortive, the posterior one perfect; *anther* 2-celled, *filament* not petaloid. *Ovary* inferior, 3-celled, placentas axile; *style* filiform. *Fruit* 1 — 3-celled, capsular or baccate. *Seeds* numerous, albuminous; *embryo* enclosed in a vitellus.

Distribution, &c. — Chiefly natives of tropical regions. *Examples:* — Zingiber, Curcuma, Elettaria, Amomum, Alpinia, Hitchenia. There are 31 genera, and 249 species.

Properties and Uses. — Chiefly remarkable for the stimulant aromatic properties possessed by their rhizomes and seeds, owing to the presence of resin and volatile oil, hence several are used as condiments, and in medicine as aromatic stimulants and stomachics. Some contain starch in large quantities, which when separated is employed for food.

Zingiber officinale, the Ginger Plant.—The so-called Ginger-root or Ginger of the shops is the rhizome of this species. The rhizomes when very young, or the young shoots of the old rhizomes, are used for preserving, and form in this state Preserved Ginger. The Ginger of the shops is found in two states, one being called *white ginger* or *uncoated ginger*, and the other, *black ginger* or *coated ginger*. The former is prepared from the rhizomes of about a year old, which when dug up, are washed, scalded, scraped, and dried. This kind is generally preferred. The latter is prepared from the rhizomes in a somewhat similar manner, but not submitted to the scraping process. The essential distinction between the two consists therefore, in White Ginger having its epidermis removed, while in Black Ginger it remains on the surface as a shrivelled membrane. Ginger is extensively used as a condiment, and also in medicine as a stimulant, stomachic, and externally as a rubefacient. *Zingiber Cassumunar* is supposed by some to be the plant from which *Cassumunar root* is obtained, but there can be but little doubt that this is obtained from a species of *Curcuma*. (See *Curcuma*).

Curcuma.—*C. longa;* the dried tubers or rhizomes of this plant constitute the turmeric of the shops. Turmeric is used as a condiment, as a test, and for dyeing yellow. It is largely employed in India, China, &c. It forms an ingredient in Curry Powder, &c. As a test to detect free alkalies, which change its colour from yellow to reddish-brown, it is sometimes employed. *C. angustifolia:* the rhizomes of this species contain a large quantity of starch, which when extracted, forms East Indian Arrow root or Curcuma Starch. This kind of arrow-root may be also obtained from other species of *Curcuma*, as *C. leucorrhiza*, *C. rubescens*, *&c.* In its effects and uses it resembles West Indian Arrowroot, but it is not so pure a starch as it. *C. Zedoaria* is supposed to yield the so-called Cassumunar roots, Zedoary roots, and Zerumbet roots of commerce. They all possess aromatic and tonic properties. Archer believes that Zerumbet and Cassumunar are derived from *C. Zerumbet*. (see *Zingiber*).

Amomum. - Several species of this genus have aromatic and stimulant seeds, which are used as spices, and in medicine in different parts of the world. The only one which is much used in this country is the *A. melegueta*, which yields the Grains of Paradise or Guinea Pepper of the shops. It is a native of the Western Coast of Africa. These seeds are much employed in Africa as a spice. The common notion that they are very injurious is erroneous. They are principally employed in this country in veterinary medicine, and for giving pungency to beer, wine, spirits, and vinegar. *A. Cardamomum* yields the fruit known as the *round cardamom*. The fruits of *A. maximum* are known as Java Cardamoms, those of *A. Korarima* as Korarima Cardamoms, those of *A. globosum* as the *large* round and the *small* round China Cardamoms. The latter are much employed in China. Many other species have similar properties.

Elettaria Cardamomum, a native of Malabar, yields the fruit which constitutes the officinal, small, or Malabar Cardamoms; these are in common use in medicine in this country, on account of their cordial and stimulating properties, and as flavouring agents. *E. major* yields Ceylon Cardamoms,

which are much employed on the Continent. Their uses and effects are similar, but they are of less value than the former.

Alpinia.—The root or rhizome known as the *greater* or *Java Galangal root*, appears to be derived from *A. Galanga* of Linnæus; that called the *lesser* or *Chinese Galangal*, from *A. chinensis*. The source of the *light Galangal* of Guibourt, is altogether unknown. The Galangals have similar properties to Ginger. The *ovoid China Cardomum* is the fruit of *A. alba*. Its seeds are used as a condiment in China.

Natural Order 251. MARANTACEÆ.—The Maranta or Arrow-root Order. — Herbaceous plants, generally without aromatic properties. They have a close resemblance to Zingiberaceæ. Their distinctive characters are, in their more irregular perianth; in one of the lateral stamens being fertile, and the other two being abortive; in the fertile stamen having a petaloid filament, an entire or 2-lobed anther, one lobe of which is sterile, and consequently the anther is described as 1-celled; in the style being petaloid or swollen; and in the embryo not being enclosed in a vitellus.

Distribution, &c. — Exclusively natives of tropical regions. *Examples:* — Thalia, Maranta, Calathea, Canna. There are 7 genera, and 160 species.

Properties and Uses. — The rhizomes of some species contain starch, which when extracted is extensively employed for food. One species has been recently described as possessing aromatic and stimulant properties, which is a marked departure from the general properties of the order, for one of the distinctive characters of this order from Zingiberaceæ is usually considered to be the absence of aromatic qualities.

Maranta arundinacea.—The rhizomes and tubers of this plant contain a large quantity of starch, which when extracted, constitutes West Indian Arrow-root, one of the purest and best known of the amylaceous substances used as food. It forms a very firm jelly, and is perhaps the most palatable and digestible starch known. The name arrow-root was originally applied to this plant from the fact of its bruised rhizome being employed by the native Indians as an application to the poisoned wounds inflicted by their arrows. The name arrow root has since been given to various other starches used as food in this country. *M. ramosissima* is also used in the East Indies for obtaining arrow-root.

Canna.—One or more species of this genus yield "Tous les mois," a very pure and useful starch, now largely consumed in this country and elsewhere. The exact species of *Canna* from which this is obtained is not certainly known. It is said to be *C. edulis*, but it is just as probable to be obtained also from *C. glauca* and *C. Archiras*. A rhizome called "African Turmeric," from its resemblance in appearance and properties to ordinary commercial Turmeric, has been recently described by Dr. Daniell in the Pharmaceutical Journal. The plant producing it is said to be the *Canna speciosa* of Roscoe. The seeds of *C. indica* are commonly known under the name of Indian Shot, from their black colour and hardness, &c.

Natural Order 252. MUSACEÆ.— The Banana or Plantain Order. — Herbaceous plants often of large size. *Leaves* with parallel curved veins (*fig.* 298), and long sheathing petioles, which together form by their union a spurious aerial stem. *Flowers* irregular, spathaceous. *Perianth* irregular, 6-parted, petaloid, superior, arranged in 2 whorls. *Stamens* 6, inserted upon the divisions of the perianth, some abortive; *anthers* 2-

celled. *Ovary* inferior, 3-celled. *Fruit* a capsule dehiscing loculicidally, or indehiscent and succulent, 3-celled. *Seeds* usually numerous, rarely 3, with mealy albumen; *embryo* not enclosed in a vitellus.

Distribution, &c.— Generally diffused throughout tropical and sub-tropical regions. *Examples:*—Heliconia, Musa, Ravenala. There are 4 genera, and 20 species.

Properties and Uses. — The fruits of some species form most important articles of food in tropical regions. Some yield valuable textile materials; and the large leaves of many are used for various purposes, such as a kind of cloth, thatching for cottages, &c. The seeds and fruits of others are used as dyeing agents in some countries.

Musa.—The fruits of some species, as those of *M. paradisiaca*, the Plantain, and *M. sapientum*, the Banana, are well known as important articles of food in many tropical regions. They owe their value as food chiefly to the presence of starch and sugar. Dr. Shier states, that a new plaintain-walk will yield 17 cwt. of starch per acre. According to Humboldt, the produce of Bananas to that of wheat is as 133·1, and to that of popatoes as 44·1. The fibrous material of the spurious stems of the different species of *Musa* may be used for textile fabrics, and in paper-making. The fibres obtained from *Musa textilis* constitute the Manilla Hemp of commerce. From the finer fibres of this plant the celebrated Indian muslins are manufactured. The young shoots of the Banana and other species of *Musa*, are boiled and eaten as a vegetable; and the large leaves are used for various domestic purposes.

Ravenala speciosa, has been called the Water-tree, in consequence of its petioles exuding when cut a quantity of watery-juice. Its seeds are edible.

Natural Order. 253. Iridaceæ.— The Iris or Corn-Flag Order (*figs.* 1033—1037).— Herbaceous plants, usually with bulbs, corms (*figs.* 227 and 228), or rhizomes (*fig.* 216). *Leaves* with parallel straight venation, usually equitant (*fig.* 216). *Flowers* spathaceous (*fig.* 1033), regular (*fig.* 1034) or irregular. *Perianth* superior (*fig.*1036), petaloid (*fig.* 1034), 6-parted, in 2 whorls (*fig.* 1033). *Stamens* 3, inserted on the outer segments of the perianth (*fig.* 1034); *anthers* 2-celled extrorse. *Ovary* inferior (*fig.* 1036), 3-celled (*fig.* 1033); *style* 1 (*fig.* 1035); *stigmas* 3, often petaloid (*figs.* 629 and 1035). *Fruit* capsular, 3-celled, 3-valved, with loculicidal dehiscence (*fig.* 690). *Seeds* numerous, with horny or hard albumen (*fig.* 1037).

Distribution, &c.— Chiefly natives of temperate and warm climates. They are found in various parts of the globe, but are most abundant at the Cape of Good Hope. *Examples:*— Sisyrinchium, Moræa, Iris, Gladiolus, Ixia, Crocus. There are 57 genera, and 557 species.

Properties and Uses.— The rhizomes of several species possess acrid properties, which renders them purgative, emetic, &c. Some have fragrant rhizomes. Others are employed as colouring agents, and some are commonly regarded as antispasmodic, carminative, &c. Many contain starch in large quantities, but as this is commonly combined with acridity, they are not generally available as food, although some are stated to be thus employed in Africa.

Fig. 1033.

Fig. 1034.

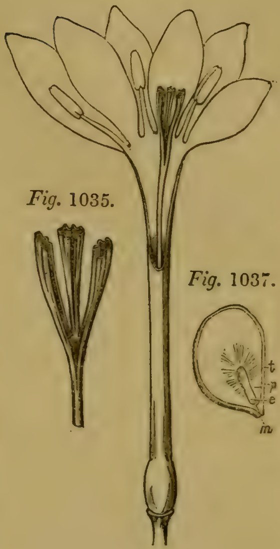


Fig. 1036.

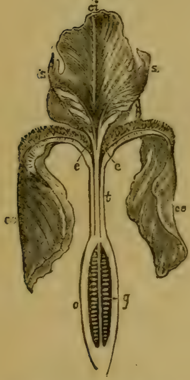


Fig. 1035.

Fig. 1037.

Fig. 1033. Diagram of the flower of a species of *Iris*, with a solitary bract or spathe below, six divisions to the perianth in two whorls, three stamens, and a three-celled ovary.——*Fig.* 1034. A flower of the Spring Crocus (*Crocus vernus*) cut open.——*Fig.* 1035. The three petaloid stigmas of the same.——*Fig.* 1036. Vertical section of the flower of *Iris germanica*. *ce*, *ce*. Two of the external divisions of the perianth. *ci.* One of the internal divisions of the perianth. *t.* Tube formed by the union of the divisions of the perianth and superior. *e*, *e*. Stamens, covered by the petaloid stigmas, *s*, *s*. *o.* Inferior ovary, with numerous ovules, *g*, attached to placentas in the axis.——*Fig.* 1037. Vertical section of a seed of the above. *t.* Spermoderm or integuments of the seed. *p.* Albumen. *e.* Embryo. *m.* Micropyle. (From Jussieu.)

Iris, Flower de Luce.—The rhizomes of several species are more or less purgative and emetic. The orris-root of the shops is the dried scraped rhizomes of *Iris florentina*, *pallida*, and *germanica*. They possess a violet odour, and are principally used in perfumery, for imparting a pleasant odour to the breath, and by the French especially, for making issue-peas. The roasted seeds of *Iris Pseud-acorus*, the Yellow Flag of this country, have been recommended as a substitute for coffee, but they are altogether wanting in the important properties of that beverage.

Crocus sativus.—The Saffron Crocus is the Karcom of the Bible. The dried stigmas of this plant with the end of the style constitute *Hay Saffron*, or when pressed together they form *Cake Saffron*. The latter is not found in the

shops. The substance sold under that name being the pressed florets of *Carthamus tinctorius*, (see *Carthamus*). Saffron contains a colouring principle called *polychroite*. The dried stigmas of some other species, as *C. aureus*, *C. odorus*, *C. luteus*, *C. vernus*, &c., are sometimes employed for the preparation of saffron in certain parts of the Continent, &c. Saffron is much used as a flavouring agent on the Continent and in the East. In this country it is principally employed as a colouring agent in pharmacy, in certain nervous affections, and as an emmenagogue. Bird-fanciers also use it, as they believe it assists the moulting of birds.

Natural Order 254. AMARYLLIDACEÆ. — The Amaryllis Order (*figs.* 1038—1040). — Bulbous or fibrous-rooted plants,

Fig. 1038.

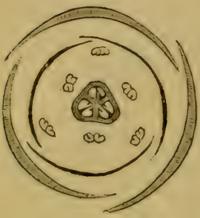


Fig. 1039.

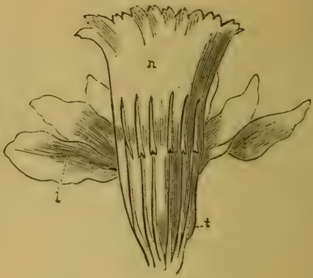


Fig. 1040.

Fig. 1041.

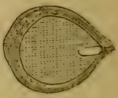


Fig. 1038. Diagram of the flower of the Spring Snowflake (*Leucojum vernum*), with six divisions to the perianth arranged in two whorls, six stamens, and a three-celled ovary with axile placentation.——*Fig.* 1039. The perianth of the Daffodil (*Narcissus Pseudo-narcissus*) cut open in a vertical manner. *t.* Tube bearing six stamens. *l.* Limb of the perianth. *n.* Corona.——*Fig.* 1040. Vertical section of the flower of the Spring Snowflake (*Leucojum vernum*).——*Fig.* 1041. Vertical section of the seed of the same.

without any aerial stem, or sometimes having a woody one. *Leaves* with parallel straight venation, linear-ensiform. *Flowers* usually on scapes, and spathaceous (*fig.* 379). *Perianth* regular or nearly so (*figs.* 379 and 1038), petaloid, superior, (*fig.* 1040), with 6 divisions, and with (*figs.* 487 and 1039 *n*) or without a corona (*fig.* 1040). *Stamens* 6, inserted on the seg-

ments of the perianth (*figs.* 1039 and 1040); *anthers* introrse (*fig.* 1040). *Ovary* inferior (*fig.* 1040), 3-celled (*fig.* 1038). *Fruit* a 3-celled, 3-valved, loculicidal capsule, with numerous seeds; or a berry with 1—3-seeds. *Seeds* with fleshy or horny albumen, and an embryo with the radicle next the hilum (*fig.* 1041).

Distribution, &c. — Natives of many parts of the world, but like the Iridaceæ, most abundant at the Cape of Good Hope. *Examples:* — Galanthus, Leucojum, Amaryllis, Narcissus, Alstrœmeria, Agave. There are 68 genera, and 400 species.

Properties and Uses.— Several plants of this order possess poisonous properties. This property is especially evident in *Hæmanthus toxicarius*, the juice of which is used by the Hottentots to poison their arrow-heads. Some yield excellent fibres. The juice of some species is saccharine, and is used in the preparation of a fermented liquor. Starch may be obtained from some species of *Alstrœmeria.* Medicinally, several species have been employed as emetics and purgatives.

Alstrœmeria pallida and some other species have succulent roots containing much starch, which when extracted, is used as a kind of arrow-root in certain parts of South America.

Agave americana, the American Aloe, Maguey, or Hundred-years' plant. The latter name was given under the erroneous idea that the Agave lived a hundred years before flowering. From the leaves of this and other species, the useful fibre known as Aloe Fibre, Pita, or Pité Hemp is obtained. It is employed for textile fabrics, and for paper-making. The juice of the leaves of *Agave americana* and other species just before flowering, contains much sugar and mucilage, and when fermented, yields a vinous acid beverage called Pulque, which is highly esteemed by the Mexicans. It has an odour something like putrid meat. A very intoxicating spirit or brandy may be obtained from the *pulque*. To this brandy the name of *mexical* or *aguardient de maguey* has been given. The unfermented juice is called *Aguamiel* or honey-water.

Natural Order 255. Hypoxidaceæ.—The Hypoxis Order.—*Diagnosis.* — This is a small order of herbaceous plants, closely allied to Amaryllidaceæ, from which they are distinguished by their habit, their dry harsh leaves, by the outer divisions of the perianth being of coarser texture than the inner, by their seeds being commonly strophiolate, and especially by having an embryo with the radicle remote from the hilum. The latter character is of most importance.

Distribution, &c. —They are scattered over various warm parts of the globe. *Examples:* — Forbesia, Hypoxis. There are 4 genera, and about 60 species.

Properties and Uses. —They are reputed bitter and aromatic, but none possess important properties. The fleshy roots of some species are eaten.

Natural Order 256. Hæmodoraceæ. — The Blood-Root Order. — Herbs, or rarely shrubby plants, with fibrous roots. *Leaves* usually equitant, ensiform. *Perianth* superior, tubular, 6-parted, regular, the divisions usually scurfy or woolly on their outside. *Stamens* 3—6, when 3, opposite the inner segments of

the perianth; *anthers* introrse. *Ovary* inferior, 1 — 3-celled. *Fruit* dehiscent or indehiscent, covered by the withered perianth. *Seeds* few or numerous, with cartilaginous albumen, and radicle remote from the hilum.

Distribution, &c. — Natives of America, the Cape of Good Hope, and Australia. *Examples*:—Hæmodorum, Lachnanthes, Conostylis, Vellozia. There are 13 genera, and 50 species.

Properties and Uses. — The roots of some species are used as dyeing agents in North America, others are edible, and some are bitter and astringent.

Hæmodorum.—The roots of several species, as those of *H. paniculatum* and *spicatum*, are roasted and eaten by the natives of certain parts of Australia. The roots contain a red colouring matter.

Lachnanthes tinctoria has a blood-red root, which is used for dyeing in North America.

Aletris farinosa is remarkable for its bitterness. It is reputed to possess tonic and stomachic properties.

Natural Order 257. TACCACEÆ. — The Tacca Order. —Perennial herbaceous plants with fleshy roots. *Leaves* with parallel veins, radical, stalked. *Perianth* tubular, regular, 6-parted, superior. *Stamens* 6, inserted into the base of the divisions of the perianth, with petaloid filaments hooded at the apex; *anthers* 2-celled, placed in the concavity below the apex of the filaments. *Ovary* inferior, 1-celled, with 3 parietal placentas projecting more or less into the interior; *styles* 3. *Fruit* baccate. *Seeds* numerous, with fleshy albumen.

Distribution, &c. —Natives of damp places in the hot parts of India, Africa, and the South Sea Islands. *Examples*:— Tacca, Ataccia. There are 2 genera, and 8 species.

Properties and Uses. — The roots are bitter and acrid, but when cultivated they become larger, and lose in some degree their acridity and bitterness and contain much starch, which when separated is used as food.

Tacca.—The roots of *T. oceanica* yield the starch known as Tacca starch, Tahiti Arrow-root, or Otaheite Salep. It may be employed as a substitute for West Indian Arrow-root. Cakes made from this starch are eaten by the natives of Otaheite and the other Society Islands. This plant is commonly cultivated in the Society Islands. *T. pinnatifida* is by some considered to be identical with the former species. Like it, the roots contain starch, which when extracted is used as food by the inhabitants of China, Cochin China, and Travancore, &c.

Natural Order 258. BROMELIACEÆ. — The Pine-Apple or Bromelia Order. — Herbs or somewhat woody plants, commonly epiphytical. *Leaves* persistent, crowded, channelled, rigid, sheathing at base, and frequently scurfy and with spiny margins. *Flowers* showy. *Perianth* superior, or nearly or quite inferior, arranged in two whorls, the outer of which has its parts commonly united into a tube; and the inner, has its parts distinct, imbricated, and of a different colour to those of the outer whorl. *Stamens* 6; *anthers* introrse. *Ovary* 3-celled;

style 1. *Fruit* (*fig.* 706, 2), capsular or indehiscent, 3-celled. *Seeds* numerous; *embryo* minute, in the base of mealy albumen, with the radicle next the hilum.

Distribution, &c. — They are mostly found in the tropical regions of America, West Africa, and the East Indies. They appear to have been originally natives of America and the adjoining islands, but they are now naturalised in West Africa and the East Indies. *Examples :* — Ananassa, Bromelia, Billbergia, Tillandsia. There are 28 genera, and about 175 species.

Properties and Uses. — They are chiefly important for yielding edible fruits, and useful fibrous materials. Some are anthelmintic, and others contain colouring matters.

Ananassa sativa, the Pine-apple (*fig.* 706, 2). The collective fruit of this species, which is called a sorosis, is the well-known and delicious fruit, the Pine-apple. A large number are now imported into Britain, chiefly from the Bahama Islands, but in flavour, &c., they are very inferior to the fruits produced in this country. The unripe fruit possesses anthelmintic properties. The fibre obtained from the leaves of this species, as well as that from one or more species of *Bromelia* and *Tillandsia*, is known under the name of *Pine-apple fibre*, and has been used for various textile fabrics, and for paper, cordage, &c.

Bromelia Pinguin possesses vermifuge properties. Its leaves yield useful fibres.

Billbergia tinctoria.—In Brazil a yellow colouring agent is obtained from its roots.

Tillandsia usneoides is commonly called Tree-beard or Old Man's Beard, from the fact of its forming a mass of dark coloured fibres, which hang from the trees in South America, like certain of the Lichens in cold climates. This article has been imported under the name of Spanish Moss, and employed for stuffing cushions, &c., mixed with horse-hair. It has been also used for stuffing birds.

2. Hypogynæ.

Natural Order 259. LILIACEÆ. — The Lily Order (*figs.* 1042 — 1047). — Herbs (*fig.* 225), shrubs (*fig.* 386), or trees (*fig.* 186), with bulbs (*figs.* 222 — 225), rhizomes (*fig.* 217), tuberous or fibrous roots. Stem simple or branched. *Leaves* with parallel veins (*fig.* 225), sessile or sheathing. *Flowers* regular (*figs.* 406, 424 and 1043). *Perianth* green or petaloid, inferior (*figs.* 424 and 1045), 6-leaved or 6-parted (*figs.* 424 and 1042). *Stamens* 6 (*figs.* 424, 510 and 1042), inserted in the perianth, or rarely on the thalamus; *anthers* introrse (*figs.* 510 and 1045). *Ovary* superior (*figs.* 424, 510 and 1045), 3-celled (*figs.* 1042 and 1046); *style* 1 (*fig.* 1045); *stigma* simple (*fig.* 424) or 3-lobed (*fig.* 633). *Fruit* a loculicidal capsule, or succulent and indehiscent, 3-celled (*fig.* 1046). *Seeds* with fleshy albumen (*fig.* 1047), numerous.

Distribution, &c.—They are widely distributed throughout the temperate, warm, and tropical regions of the globe. *Examples :* — Tulipa, Fritillaria, Lilium, Funkia, Phormium, Aloe, Yucca, Allium, Scilla, Hyacinthus, Zephrya, Asphodelus, Aphyllanthes, Xanthorrhœa, Wachendorfia, Asparagus, Tupistra, Ophiopogon. There are 147 genera, and about 1200 species.

Fig. 1042.

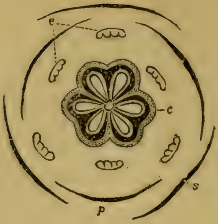


Fig. 1043.

Fig. 1044.

Fig. 1045.

Fig. 1046.

Fig. 1047

Fig. 1042. Diagram of the flower of a species of Lily. *s.* The three outer divisions of the perianth. *p.* The three inner. *e.* The stamens. *c.* Three-celled ovary.——*Fig.* 1043. Flowering stem, and portion of the succulent leaf of the Socotrine Aloes (*Aloe socotrina*).——*Fig.* 1044. Flower of the Crown Imperial (*Fritillaria imperialis*), with half of the perianth removed.——*Fig.* 1045. Vertical section of a flower of Solomon's Seal (*Polygonatum multiflorum*).——*Fig.* 1046. Transverse section of the ovary of the White Lily (*Lilium candidum*).——*Fig.* 1047. Vertical section of the seed of the Crown Imperial (*Fritillaria imperialis*).

Properties and Uses.—The plants of this order frequently possess very important properties, but there is no great uniformity in them. Some are purgative; others emetic; others diuretic, diaphoretic, stimulant, acrid, &c. Several yield astringent products, and valuable fibres. The bulbs, young shoots, and seeds of several, are eaten.

Lilium.—The bulbs of some species, as those of *L. tenuifolium*, *kamtschaticum*, and *spectabile*, are commonly eaten in Siberia.

Phormium tenax.—This plant is a native of New Zealand. The fibre obtained from its leaves possesses great strength, and is commonly known under the name of New Zealand Flax. It is much used for twine and cordage, and occasionally for linen, &c. Its root has been recommended as a substitute for Sarsaparilla.

Sanseviera zeylanica and other species, produce very strong and tough fibres, which are known under the names of African Hemp or Bowstring Hemp.

Yucca gloriosa and other species which are commonly known under the name of Adam's Needle, yield fibres, but these are but little used.

Aloe.—The species of this genus have succulent leaves (*Fig*. 1043). The purgative drug Aloes is the inspissated juice of the parallel brownish-green vessels found beneath the epidermis of the leaves. Several commercial varieties are known, but the origin of some is not accurately determined. *Aloe vulgaris* or *barbadensis* yields the kind called Barbadoes Aloes. *A. socotrina* and *purpurascens*, probably yield both Socotrine and Hepatic Aloes, for, as shown by the late Dr. Pereira, the difference between these two kinds may be readily accounted for by difference of preparation in the two respectively. Thus, when the juice of the Socotrine Aloes plant is inspissated by artificial heat, the product resembles Socotrine Aloes; but when solidified without the aid of artificial heat, it resembles commercial Hepatic Aloes. *Cape Aloes* is yielded by *A. spicata* and other species; *Indian Aloes*, by *A. indica* and others. Other commercial varieties of Aloes are known as Horse or Caballine Aloes, Mocha Aloes, and Curaçoa Aloes. Their source is not accurately known. Aloes is used in small doses as a tonic, and in larger doses as a purgative and emmenagogue.

Allium.—The bulbs, &c., of several species of this genus are well known dietetical articles, and are extensively used as condiments under the names of Onion, Garlic, Leek &c. Garlic and Onion are sometimes employed in medicine, thus externally applied, they are rubefacient, &c., and internally administered, they are stimulant, expectorant, diuretic, and somewhat anthelmintic. All the species contain an acrid volatile oil, containing sulphur as one of its ingredients. Some species when cultivated in warm dry regions lose much of their acridity and powerful taste, as the Portugal, Spanish, and Egyptian Onions. *A. sativum* is the Common Garlic; *A. Cepa*, the Onion; *A. Porrum*, the Leek; *A. Schœnoprasum*, the Chive; *A. Scorodoprasum*, the Rocambole; *A. asculonicum*, the Shallot.

Camassia esculenta has edible bulbs, which are used by the North American Indians under the name of *Quamash*. They are also known as Biscuit-roots.

Urginea Scilla or *Scilla maritima*.—The bulb of this species is our officinal Squill. It is a valuable medicine; in small doses acting as an expectorant and diuretic, and in larger doses it is emetic and cathartic. In excessive doses it is a narcotico-acrid poison. Some other species seem to possess analogous properties. Two active principles have been obtained from the Squill by M. Mandet — one which produces expectorant and diuretic properties, and not poisonous; the other, an irritating poison; the former is called *scillitine*, the latter *skuleine*.

Xanthorrhœa. — The species of this genus are commonly known in New South Wales, where they are natives, as the Grass-trees. The tops of these plants afford fodder for cattle, and their young leaves and buds are eaten as a vegetable. From *X. arborea*, *Hastile*, and others, two resins are obtained; one of which is known as Yellow resin of New Holland or Botany Bay resin, the other, as the Red resin of New Holland or Black-boy gum. The latter appears to be the produce of *X. Hastile*. Both resins exude spontaneously from the trunks of the trees. They both possess a fragrant balsamic odour. They have been recommended for use in the preparation of pastilles, and medicinally in those cases where tolu and other balsams are employed.

Asparagus officinalis, Asparagus. — The young succulent shoots called *turios*, when boiled, are highly esteemed as an article of food. These, and the roots, and flowering stems, are sometimes employed as diuretics. Asparagus is also popularly employed as a lithic. The roasted seeds have been used as a substitute for coffee.

Dracæna Draco, the Dragon Tree of Teneriffe (*fig*. 186), yields a red resin resembling Dragon's Blood, but it is not known in commerce. (See *Calamus*

and *Pterocarpus.*) The roots of *D. terminalis*, the Ti Plant, are baked, and eaten largely by the inhabitants of the Sandwich Islands. A fermented beverage is also obtained from its juice. Its leaves are also employed as fodder for cattle, and for clothing and other domestic purposes.

Polygonatum officinale or *vulgare*. — The rhizomes of this, and probably those of *P. multiflorum*, are sold in the herb shops under the name of Solomon's Seal. They are employed as a popular application to remove the marks from bruised parts of the body.

Ruscus aculeatus, Butcher's Broom (*Fig.* 386), has aperient and diuretic roots, which were formerly much employed in visceral diseases. The roasted seeds have been employed as a substitute for coffee.

Natural Order. 260. MELANTHACEÆ or COLCHICACEÆ.—The Colchicum Order (*figs.* 1048—1051). — Herbs, with bulbs

Fig. 1048.

Fig. 1049.

Fig. 1050.

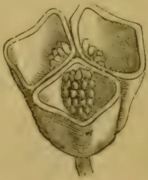


Fig. 1051.

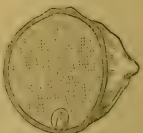


Fig. 1048. The flowering plant of the Meadow Saffron (*Colchicum autumnale*). *Fig.* 1049. Diagram of the flower of the above, with six divisions to the perianth, arranged in two whorls; six stamens; and an ovary composed of three carpels.——*Fig.* 1050. Transverse section of the fruit of the above.——*Fig.* 1051. Vertical section of the seed.

corms (*figs.* 229 and 1048), tuberous or fibrous roots. *Flowers* regular (*fig.* 1048), usually hermaphrodite, rarely unisexual. *Perianth* inferior, white, green, or purple, petaloid (*fig.* 1048), 6-parted or 6-leaved. *Stamens* 6 (*figs.* 507, 1048 and 1049); *anthers* extrorse (*fig.* 507). *Ovary* superior or nearly so, 3-celled (*fig.* 1049); *style* 3-parted (*fig.* 1048). *Fruit* 3-celled (*fig.* 1050), 3-valved, with commonly septicidal dehiscence (*fig* 654), sometimes loculicidal. *Seeds* with a membranous testa; *embryo* minute, in fleshy albumen (*fig.* 1051).

Distribution, &c.— Generally diffused, but most abundant in

Europe, North America, and the northern parts of Asia. *Examples :*— Tofieldia, Helonias, Asagræa, Veratrum, Uvularia, Colchicum. There are 31 genera, and 130 species.

Properties and Uses. — The plants of this order are almost universally poisonous owing to the presence of powerful alkaloids. In proper doses several are valuable medicines, possessing emetic, purgative, diuretic, acrid, and narcotic properties.

Asagræa officinalis. — This plant, a native of Mexico, is the principal, if not the only source of the Sabadilla, Cevadilla, or Cabadilla of the shops. This consists of fruits and seeds. The seeds are officinal, they are principally employed as a source of the alkaloid Veratria. Veratria has been used externally as a rubefacient, in rheumatism, gout, and neuralgic affections, and also internally in similar affections in doses of one twelfth to one sixth of a grain. It is a most powerful poison. Cebadilla seeds have been employed internally as an anthelmintic. They are called *lice seeds* by the Germans, because when powdered and applied externally, they destroy vermin.

Veratrum. — *V. Sabadilla* is thought by some to be one of the sources of Sabadilla. The rhizomes of *V. album* are commonly known as White Hellebore roots. They contain the alkaloid Veratria, and another alkaloid named Jervin. White Hellebore is a narcotico-acrid poison. It has been employed externally as an errhine, and for destroying vermin; and internally as a purgative and anodyne in gout, &c. The rhizome of *V. viride*, Green Hellebore, is now much employed in the United States under the name of American Hellebore, Swamp Hellebore, and Itch Wood, as an arterial sedative in inflammatory affections. In its local action it resembles White Hellebore.

Uvularia. —The species of this genus are said not to possess the usual poisonous properties of the Melanthaceæ, but to be simply astringent in their action.

Colchicum autumnale, the Colchicum or Meadow Saffron. — Both the seeds and corms of this plant are employed medicinally in gout and rheumatism. In improper doses they act as narcotico-acrid poisons. They owe their properties to a peculiar alkaloid, called Colchicia. The once celebrated French nostrum for gout, called *Eau médicinale d'Husson*, owed its properties to Colchicum. The *Hermodactyls* of the Greek physicians and Arabians, and which were largely employed by them in diseases of the joints, have been shown by Planchon to be the corms of *C. variegatum*, the source of the Hermodactyls of the present day. Some other Hermodactyls had a different origin.

Natural Order 261. Gilliesiaceæ. — The Gilliesia Order. — Small herbaceous bulbous plants, with grass-like leaves. *Flowers* perfect, umbellate, spathaceous. *Perianth* in two whorls, the outer consisting of 6 or 8 petaloid leaves, the inner minute, and either a single lip-like organ, or urn-shaped and 6-toothed. The outer portion of the perianth is regarded by Lindley as a whorl of bracts. *Stamens* 6, all fertile, or 3 sterile. *Ovary* superior, 3-celled. *Fruit* capsular, 3-celled, loculicidal. *Seeds* numerous, with a black brittle testa; *embryo* curved, in fleshy albumen.

Distribution, &c. — They are natives of Chili. There are 2 genera, Gilliesia and Miersia, and 5 species. Their properties and uses are unknown.

Natural Order 262. Pontederaceæ. — The Pontederia Order. — Aquatic plants. *Leaves* sheathing at the base, with occasionally dilated petioles. *Flowers* irregular, spathaceous. *Perianth* inferior, 6-parted, petaloid, tubular. *Stamens* 3 or 6, inserted on the segments of the perianth; *anthers* introrse. *Fruit*

capsular, occasionally somewhat adherent to the persistent perianth. *Seeds* numerous, with mealy albumen.

Distribution, &c.—They are natives of the East Indies, Africa, and America. *Examples:*—Leptanthus, Pontederia. There are 6 genera, and 30 species. Their properties are unimportant.

Natural Order 263. MAYACEÆ.—The Mayaca Order.—*Diagnosis.*—Small moss-like plants growing in damp places. They are closely allied to Commelynaceæ, from which they differ in habit, in their 1-celled anthers, in their 1-celled ovary and capsule with parietal placentas, and in their carpels being opposite to the inner segments of the perianth.

Distribution, &c.—They are found in America from Brazil to Virginia. *Mayaca* is the only genus, of which there are 4 species. Their properties and uses are unknown.

Natural Order 264. COMMELYNACEÆ.—The Spider-Wort Order.—Herbs with flattened, narrow, usually sheathing leaves. *Perianth* inferior, more or less irregular, in 6 parts arranged in two whorls; the outer parts being green, persistent, and opposite to the carpels; the inner petaloid. *Stamens* 6 or 3, some generally abortive, hypogynous; *anthers* 2-celled, introrse. *Ovary* 3-celled, superior; *style* 1. *Capsule* 2—3-celled, 2—3-valved, with loculicidal dehiscence and axile placentation. *Seeds* few, with a linear hilum; *embryo* shaped like a pulley, remote from the hilum, in dense fleshy albumen.

Distribution, &c.—They are chiefly natives of India, Africa, Australia, and the West Indies. *Examples:*—Commelyna, Tradescantia, Cyanotis, Flagellaria. There are 16 genera, and 260 species.

Properties and Uses.—Their properties are unimportant, The rhizomes of some species, as those of the *Commelyna tuberosa*, *angustifolia*, and *striata*, contain much starch, and in a cooked state are edible. Some species have been reputed astringent and vulnerary, and others emmenagogue, &c.; but they require no particular notice from us.

Natural Order 265. XYRIDACEÆ.—The Xyris Order.—Sedge-like herbaceous plants. *Leaves* radical, sheathing, ensiform or filiform. *Flowers* perfect, in scaly heads. *Perianth* inferior, of 6 parts arranged in two whorls,—the outer glumaceous, distinct, and opposite the carpels; the inner petaloid, and united. *Stamens* 6, 3 being fertile and inserted on the petaloid perianth; *anthers* extrorse. *Ovary* superior, 1-celled, with parietal placentas. *Capsule* 1-celled, 3-valved. *Seeds* numerous, orthotropous; *embryo* minute, on the outside of fleshy albumen.

Distribution, &c.—Exclusively natives of tropical and subtropical regions. *Examples:*— Xyris, Rapatea. There are 5 genera, and 70 species.

Properties and Uses.—Unimportant. The leaves and roots of some species of *Xyris* have been employed in certain cutaneous affections.

Natural Order 266. PHILYDRACEÆ.—The Water-wort Order. —Herbs with fibrous roots. *Leaves* equitant, ensiform, sheathing. *Flowers* surrounded by spathaceous persistent bracts, solitary. *Perianth* inferior, in 1 whorl, 2-leaved, petaloid. *Stamens* 3, 2 of which are abortive; *filaments* united. *Ovary* superior, 3-celled, with axile placentas. *Fruit* capsular, with loculicidal dehiscence. *Seeds* numerous, with an embryo in the axis of fleshy albumen.

Distribution, &c. — They are natives of China and New Holland. There are 2 genera, Philydrum and Hetæria, and 2 species. Their properties and uses are unknown.

Natural Order 267. JUNCACEÆ.—The Rush Order (*figs.* 1052, 1053). — Sedge or grass-like herbs, with tufted or fibrous

Fig. 1052.

Fig. 1053.

Fig. 1052. Flower of a species of Wood-rush (*Luzula*), with an inferior perianth of 6 divisions, 6 stamens, and a superior ovary with 1 style and 3 stigmas. *Fig.* 1053. Vertical section of the seed of the above.

roots. *Leaves* with parallel veins, either fistular, or more or less flattened and grooved. *Flowers* regular (*fig.* 1052), usually glumaceous, or sometimes petaloid. *Perianth* inferior, 6-parted (*fig.* 1052), persistent. *Stamens* 6 (*fig.* 1052), or 3, perigynous; *anthers* introrse, 2-celled. *Ovary* superior (*fig.* 1052), 1—3-celled; *style* 1 (*fig.* 1052); *stigmas* 3 (*fig.* 1052), or 1. *Fruit* capsular, 3-valved, with loculicidal dehiscence, and with 1 or many seeds in each cell; rarely 1-celled, 1-seeded, and indehiscent; *embryo* very minute, in fleshy or horny albumen (*fig.* 1053).

Distribution, &c. — A few are found in tropical regions, but the mass of the order inhabit cold and temperate climates. *Examples*:—Luzula, Juncus, Narthecium. Lindley enumerates 19 genera, and 200 species.

Properties and Uses. — Their medicinal properties are unim-

portant, although some have a reputation as anthelmintics and diuretics. The pale cellular tissue at the base of some of the leaves of certain species are occasionally eaten. The chief use to which the plants of this order are applied is, in making floor-mats, and for the bottoms of chairs, &c. The leaves of the species of *Juncus* are employed for these purposes. The pith of the fistular leaves of *Junci* are employed for the wicks of rush-lights.

Natural Order 268. ORONTIACEÆ or ACORACEÆ.—The Orontium or Sweet-flag Order.—Herbaceous plants. *Flowers* perfect, arranged on a spadix, and with or without a spathe. *Perianth* absent, or composed of scales, which are inferior. *Stamens* equal in number to the scales of the perianth, 4—8, hypogynous or perigynous. *Ovary* superior, 1 or more celled. *Fruit* baccate. *Seed* with an axile embryo which is cleft on one side; usually with fleshy or mealy albumen, rarely without albumen. This order is commonly regarded as a division of the Araceæ, but we place it here according to the views of Lindley, on account of its plants possessing perfect flowers.

Distribution, &c. — They are found in cold, temperate, and tropical regions. *Examples:*— Calla, Dracontium, Symplocarpus, Orontium, Acorus. There are 18 genera, and about 70 species.

Properties and Uses. — The generality of the plants of this order have acrid properties. The acridity may usually be got rid of by drying and by heat, and then the rhizomes of some species may be eaten. Some are aromatic stimulants; others antispasmodic, expectorant, and diaphoretic.

Calla palustris has acrid rhizomes, but by drying, washing, grinding, and baking, they have been made into a kind of bread in Lapland.

Symplocarpus fœtidus, Skunk Cabbage. — The root has a very fœtid odour, especially when fresh. It is considered in the United States as an efficacious nervous stimulant, and has been used in spasmodic asthma, hooping-cough, catarrh in old people, and in other diseases. Its properties are much impaired by keeping.

Acorus Calamus, Sweet Flag. — The rhizome is an aromatic stimulant, and is regarded by some as a valuable medicine in agues, and as a useful adjunct to other stimulants and bitter tonics. It is reputed to be sometimes employed by the rectifiers of gin. The volatile oil which may be obtained from it by distillation, is employed for scenting snuff, and in the preparation of aromatic vinegar.

Natural Order 269. PALMACEÆ.—The Palm Order (*figs.* 1054—1059) — Trees or shrubs, with simple (*fig.* 178, 1) or rarely branched trunks (*fig.* 185). *Leaves* terminal (*figs.* 178 and 185), large, with sheathing stalks. *Flowers* perfect (*figs.* 1056 and 1057), or unisexual (*figs.* 1054 and 1055), arranged generally on a branched spadix (*fig.* 394), which is enclosed by a spathe. *Perianth* inferior, in two whorls, each of which is composed of three parts (*figs.* 1054 and 1055). *Stamens* 6 (*figs.* 1054 and 1055), 3, or numerous, perigynous. *Ovary* superior (*figs.* 1056 and 1057), 1—3-(*figs.* 1055 and 1057)

celled. *Fruit* nut-like, baccate, or drupaceous (*fig.* 1058). *Seeds* with a minute embryo (*fig.* 1058 *e* and 1059), in a cavity of the albumen (*fig.* 1058 *d*); *albumen* fleshy, or horny (*figs.* 1058 *c* and 1059), often ruminate (*fig.* 740 *p*).

Fig. 1054.

Fig. 1056.

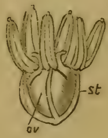


Fig. 1057.

Fig. 1055.

Fig. 1058.

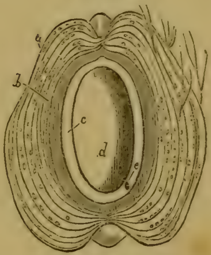


Fig. 1059.

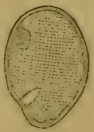


Fig. 1054. Diagram of the staminate flower of the Fan Palm (*Chamærops*), with six divisions to the perianth, and six stamens.——*Fig.* 1055. Diagram of the pistillate flower of the same, with six divisions to the perianth, and a 3-celled ovary.——*Fig.* 1056. Hermaphrodite flower of the Blue Palmetto (*Chamærops hystrix*), with the perianth removed. *ov.* Ovary. *st.* Stamens. *Fig.* 1057. The same, with three of the stamens removed, so as to exhibit more completely the three carpels composing the pistil. *st.* Stamens. *c.* Carpels.——*Fig.* 1058. Vertical section of the fruit of the Cocoa-Nut Palm (*Cocos nucifera*). *a.* Two outer layers or husk of the pericarp. *b.* Endocarp, or inner layer, or shell. *c.* Albumen. *d.* Cavity in the albumen. *e.* Embryo.——*Fig.* 1059. Vertical section of the seed of the Fan Palm.

Distribution, &c. — Most of the plants are tropical, but a few occur in temperate regions. *Examples:* — Chamædorea, Leopoldinia, Areca, Saguerus, Calamus, Sagus, Lodoicea, Hyphæne, Chamærops, Phœnix, Acrocomia, Attalea, Elais, Cocos, Phytelephas. Lindley enumerates 73 genera, and 400 species.

Properties and Uses. — Of all orders of plants, there is none, with the exception of the Grasses, that is so valuable to man, as regards their dietetical and economical applications, as the Palms, They supply him with sugar, starch, oil, wax, wine, resin, astringent matters, and edible fruits and seeds. Their terminal leaf-

buds, when boiled, are eaten as a vegetable. Their leaves are applied in various ways, as for thatching their habitations, materials for writing upon, in the manufacture of hats, matting, &c.; their wood is applied to many useful purposes ; the fibres of their petioles and fruits supply materials for cordage, cloth, and various textile fabrics; and the hard albumen of their seeds is applicable in many ways. In a medicinal point of view they are of very much less importance; indeed, they do not supply any important article of the Materia Medica of Europe, although in tropical countries they are of more value, and in frequent use as medicinal agents.

Leopoldinia Piassaba. — The persistent petiole-bases of this Palm terminate in long pendulous beards of bristle-like fibres ; these are cut off from the young plants after having been previously combed out by means of a rude comb, and now form an important article of commerce in Brazil. The fibres are known under the names of Piassaba or Piaçava, Para Grass, or Monkey Grass. They are chiefly used for brooms, brushes for cleaning, &c. According to Spruce, the pulpy envelope of the sarcocarp of the ripe fruit, yields a delicious drink resembling cream in colour and taste.

Euterpe montana is one of the Cabbage Palms. It is so called from the circumstance of its young leaf-buds being boiled and eaten as a vegetable. From the fruits of other species, as *E. edulis* and *Assai*, pleasant beverages are prepared.

Areca Catechu, the Catechu or Betel Nut Palm. — The seed is known under the names of the Betel, Areca, and Pinang Nuts. In the south of India an extract is made from Areca nuts. This extract constitutes one of the commercial varieties of Catechu, and is commonly known as Colombo or Ceylon Catechu, although it is doubtful whether any Catechu is prepared in that island. In its properties and uses it resembles the Catechu obtained from *Acacia Catechu* (See p. 531). Charcoal prepared from the Areca nut is termed *Areca-nut charcoal*, and is used in this country as a tooth-powder. It has no value over that of ordinary charcoal. The Betel Nut is one of the ingredients in the famed masticatory of the East, called *Betel.* (See *Chavica Betel.*) *A. oleracea* is the West Indian Cabbage Palm. Its young terminal bud is boiled, and eaten as a vegetable.

Ceroxylon or *Iriartea andicola.* — The trunk, and axils of the leaves of this palm secrete wax, which may be applied to many useful purposes. It is a native of South America.

Copernicia cerifera, the Carnauba Palm, is a native of the Brazils. On the lower surface of its leaves wax is secreted, which is occasionally imported into this country under the name of Carnauba or Brazilian Wax.

Caryota urens. — From this palm sugar may be procured, and its juice when fermented, forms a kind of toddy or palm wine. From the trunks of the old trees a kind of Sago is obtained in Assam.

Mauritia vinifera, the Muriti Palm, and *M. flexuosa*, yield toddy.

Saguerus saccharifer, the Gommuti Palm, supplies abundance of palm sugar in the Moluccas and Philippines. Palm sugar is generally obtained from the juice which flows out from the different Palms upon wounding their spathes and surrounding parts. It is commonly known in India by the name of Jaggery. The juice of the Gommuti Palm when fermented, produces an intoxicating liquid or toddy. In Sumatra it is termed *neva*, and a kind of arrack is distilled from it in Batavia. From the trunk of this Palm, when exhausted of its saccharine juice, a good deal of our commercial Sago is obtained. A single tree will yield from 150 to 200 pounds of Sago. The juice of the fruit is very acrid. The stiff strong fibre known under the name of Gommuti or Ejow fibre, is obtained from the *Saguerus saccharifer.*

Sagus.—From the trunks of *S. lævis*, *S. genuina*, and other species, the principal part of our Sago is obtained. From the former, as much as 800 lbs. may be produced from a single plant. Sago is imported into this country from Singapore. The average importation for some years has exceeded 4000 tons.

Corypha umbraculifera, the Talipot Palm, also yields Sago in Ceylon.

Borassus flabelliformis, the Palmyra Palm.—From the juice of this Palm,

toddy is obtained in large quantities in India. Palmyra fibres are obtained from its leaves, and Palmyra wood from its trunk.

Phœnix.—P. dactylifera is the Date Palm. The fruits called Dates are nutritious, and afford the principal food of the inhabitants of some parts of Africa and Arabia. Animals are also fed upon them. They are imported into this country, and used as an article for the dessert, but they are not much esteemed. About ten tons annually are received. They have been lately used as a food for cattle, but at present, their price is too high to allow of any great consumption for such a purpose. The Date Palm is the Palm commonly referred to in Scripture. Sugar and toddy are obtained from its juice. *P. sylvestris*, the Wild Date Palm, is the plant from which the largest quantity of palm sugar is obtained. It is a native of India, where, it is said, 130,000,000 pounds of sugar are annually extracted from it. Palm sugar generally resembles cane sugar in flavour. The total amount of palm sugar obtained from the different kinds of Palms, has been estimated by Johnston at 220,000,000 pounds. *Phœnix farinifera* yields an inferior kind of Sago, which is used in some parts of India.

Calamus. — Several walking-canes are obtained from species of this genus, as *C. Zalacca*, the Malacca cane ; *C. Scipionum* (*Rotang*), and *C. Rudentum*, Rattan canes. Partridge canes and Penang lawyers are the produce of undetermined species. The fruit of *C. Draco*, and probably other species, is the chief source of the astringent resinous substance known as Dragon's Blood. (See also *Pterocarpus Draco*, and *Dracæna Draco*).

Hyphæne thebaica, the Doum Palm of Egypt (*fig.* 185). The pericarp of its fruit resembles gingerbread; hence this plant is sometimes known as the Gingerbread tree.

Chamærops humilis is the only Palm found wild in Europe. It supplies fibres which have been used as a substitute for horse-hair, and in Sicily the different parts of this plant are applied to various purposes, as walking-canes, and for the making of hats, baskets, &c. The materials employed for the Brazilian chip or grass hats are obtained from *C. argentea.*

Attalea funifera. — The fruits of this species are largely imported into this country, and constitute the Coquilla nuts of commerce. The pericarp is very hard, and forms a useful material for the handles of doors, drawers, sticks, umbrellas, &c. The pendulous fibres of the petioles supply a material closely resembling Piassaba (see *Leopoldinia*); in fact, this Palm was, till recently, regarded as the source of Piassaba. Other species appear to yield similar fibres. From the seeds of *A. Cahouni*, the Cahoun Palm, a fatty oil may be obtained. They have been lately imported for that purpose.

Phytelephas macrocarpa — The hard albumen of the seed of this Palm constitutes the vegetable ivory of commerce. It is used extensively by the turners. The fruits containing the seeds present some resemblance to negroes' heads, and are hence termed *Cabeza del negro.*

Elais guineensis and *E. melanococca*, the Guinea Oil Palms. — The sarcocarp of the drupaceous fruits of these Palms abounds in oil, which when extracted is known as Palm Oil. This is a solid butter-like oil, of a rich orange-yellow colour, and is extensively used in this country in the manufacture of soap and candles, and for lubricating the wheels of railway-carriages, &c. In Africa it is used as food by the natives. The hard stony putamen of the same fruits yields a limpid oil. Palm wine may be also prepared from the juice which flows from the wounded spathes of these Palms.

Cocos nucifera, the Cocoa or Coco-nut Palm.—This is perhaps the most valuable of all the Palms. Sugar called Jaggery is largely obtained from the juice which flows out when its spathes and spadix are injured. *Toddy* and *arrack* are prepared to a great extent from the fermented juice. The albumen of the seeds, and the liquid portion within this (cocoa-nut milk), form an important part of the food of the inhabitants of tropical regions. The Cocoa-nut is also largely consumed in this country. From this albumen, the concrete oil, known as *Cocoa-nut oil* or *Cocoa-nut butter*, is obtained It is extensively employed for making candles and soap. In India it is much esteemed as a pomatum, but its unpleasant odour and the rancid character which it soon acquires, prevent its use in this country for such a purpose. From the fibrous portion of the pericarp of the Cocoa-nut, the strong fibres called Coir or Cocoa-nut fibres are obtained. Coir is remarkable for its durability. and is accordingly much used for cordage, fishing-nets, matting, scrubbing-brushes, &c. The wood of the Cocoa-nut is very hard, handsome, and durable, and is used for several purposes under the name of Porcupine Wood.

Natural Order 270. JUNCAGINACEÆ. — The Arrow-grass Order. — Herbaceous marsh plants. *Leaves* with parallel veins. *Flowers* perfect, whitish or greenish. *Perianth* small, more or less scaly, inferior, in two whorls, each containing three pieces. *Stamens* 6 ; *anthers* usually extrorse. *Carpels* 3—6, separate or more or less united ; ovules 1—2. *Fruit* dry, separating into as many parts as there are carpels. *Seeds* attached to axile or basal placentas, without albumen ; *embryo* straight, with a lateral cleft (*figs.* 744 and 745).

Distribution, &c. — Found more or less in nearly all parts of the world, but most abundant in temperate and cold regions. *Examples* :—Triglochlin, Potamogeton, Ouvirandra. There are 7 genera, and 44 species. Their properties are unimportant.

Natural Order 271. ALISMACEÆ.—The Alisma Order (*figs.* 1060 and 1061). — Swamp or floating plants. *Leaves*

Fig. 1060. *Fig.* 1061.

Fig. 1060. Flower of a species of *Alisma*, with an inferior perianth, arranged in two whorls, each consisting of three parts ; six stamens ; and numerous carpels.——*Fig.* 1061. Vertical section of the same.

narrow or with an expanded lamina, parallel-veined. *Flowers* perfect (*figs.* 1060 and 1061), or very rarely unisexual. *Perianth* inferior, arranged in two whorls, each consisting of three parts (*fig.* 1060) ; the outer whorl herbaceous, the inner coloured. *Stamens* few (*fig.* 1060), or numerous ; *anthers* introrse. *Ovaries* several (*fig.* 1060), superior, 1-celled ; *ovules* solitary, or 2-superposed ; *placentas* axile or basal (*fig.* 1061). *Fruit* dry. *Seeds* without albumen ; *embryo* undivided, curved.

Distribution, &c.—They are principally found in the northern parts of the world. *Examples* :—Alisma, Sagittaria, Actinocarpus. There are 3 genera, and 50 species.

Properties and Uses.—Of little importance. Many have fleshy mealy rhizomes, which are edible when cooked. Others possess astringent properties.

Natural Order 272. BUTOMACEÆ. — The Butomus or

Flowering Rush Order (*figs.* 1062 and 1063). — Aquatic plants with parallel-veined leaves, sometimes milky. *Flowers* perfect (*figs.* 575, 621, and 1062), showy. *Perianth* inferior, of six pieces, arranged in two whorls (*fig.* 1062), the inner being coloured. *Stamens* few (*fig.* 1062) or numerous. *Ovaries* superior (*fig.* 1062), 3—6 (*fig.* 575), or more; more or less distinct: *ovules* numerous, arranged all over the inner surface of the ovaries (*fig.* 621). *Fruit* many-seeded, separating more or less into as many parts as there are component carpels (*fig.* 577). *Seeds* without albumen (*fig.* 1063).

Fig. 1062.

*Fig.*1063.

Fig. 1062. A flower of the Flowering Rush (*Butomus umbellatus*), with a 6-partite inferior perianth, arranged in two whorls; nine stamens; and six carpels.——*Fig.* 1063. Vertical section of the seed of the same.

Distribution, &c. — A few occur in tropical countries, but the mass of the order inhabit the northern parts of the world. *Examples:* — Butomus, Lymnocharis. There are 4 genera, and 7 species.

Properties and Uses.— Of little importance. *Butomus umbellatus*, the Flowering Rush, possesses acrid and bitter properties, and was at one time used in medicine. The roasted rhizome is edible.

3. Diclines.

Natural Order 273. PANDANACEÆ.—The Screw-pine Order. — Palm-like trees (*fig.* 178, 2), or shrubs. *Leaves* sheathing, imbricated, and spirally arranged in 3 rows, simple or pinnate. *Flowers* unisexual or polygamous, numerous, arranged on a spadix, with numerous spathaceous bracts. *Perianth* absent, or scaly. *Stamens* numerous; *anthers* 2—4-celled. *Ovaries* 1-celled; *ovules* solitary or numerous, on parietal placentas. *Fruit* consisting of a number of 1-seeded fibrous drupes; or of many-celled, many-seeded berries. *Embryo* minute, solid, at the base of fleshy albumen.

Distribution, &c.—Exclusively tropical plants. *Examples:* — Pandanus, Carludovica, Nipa, Cyclanthus. There are 24 genera, and about 75 species.

Properties and Uses.—None possess any very active properties. *Pandanus* has edible seeds. The juice which flows from the wounded spadices of *Nipa*, when fermented, furnishes a kind of wine. The fruit of *Nipa fruticans* is the Atap of India. The

unexpanded leaves of *Carludovica palmata* furnish the material employed in the manufacture of Panama hats.

Natural Order 274. TYPHACEÆ. — The Bulrush Order. — Herbs growing in watery places. *Leaves* rigid, linear, sessile, parallel-veined. *Flowers* monœcious, arranged on a spadix or in heads, without a spathe. No true perianth, merely scales or hairs. *Male flower* with 1—6, distinct or monadelphous stamens, with long filaments, and innate anthers. *Female flower* a solitary 1-celled ovary, with a single pendulous ovule. *Fruit* indehiscent. *Seed* with mealy albumen ; *embryo* axial, with a cleft on the side ; radicle next the hilum.

Distribution, &c. — A few are found in tropical and warm climates, but they are most abundant in the northern parts of the world. *Examples :* — Typha, Sparganium. There are 2 genera, and 13 species.

Properties and Uses. — Unimportant. The young shoots of *Typha latifolia* and *angustifolia* are sometimes boiled, and eaten like Asparagus. Their rhizomes are also edible. Their pollen is inflammable. The pollen of some species of *Typha* is edible ; thus, that of *T. elephantina* is made into a kind of bread in Scinde, and that of *T. utilis* in New Zealand. Some species are said to be astringent and diuretic.

Natural Order 275. ARACEÆ.—The Arum Order (*figs.* 1064—1067). — Herbs or shrubs, with an acrid juice, and subterranean tubers, corms, or rhizomes (*fig.* 1064). *Leaves* sheathing (*fig.* 1064 *l*), usually net-veined, simple, or rarely compound. *Flowers* monœcious, arranged on a spadix (*figs.* 380 and 1065), within a spathe (*fig.* 380). *Perianth* none (*fig.* 1065). *Male flower :— Stamens* few or numerous ; *anthers* extrorse (*fig.* 489), sessile (*fig.* 489), or upon very short filaments. *Female flower :— Ovary* (*fig.* 1066), 1-celled, or rarely 3 or more celled. *Fruit* succulent (*fig.* 1064 *c*). *Seeds* pulpy, with mealy or fleshy albumen (*fig.* 1067), or rarely exalbuminous ; *embryo* axial, slit on one side.

Distribution, &c.—They abound in tropical countries, but a few occur in cold and temperate regions. *Examples :*—Cryptocoryne, Arum, Colocasia, Caladium, Dieffenbachia, Richardia. There are 30 genera, and 170 species.

Properties and Uses. — The plants of this order are all more or less acrid, and often highly poisonous. This acrid principle is frequently volatile, or decomposed by heat; hence it may be in such cases more or less destroyed by drying or exposing to heat the parts in which it is present. The best method of getting rid of the acridity is, however, by boiling in water, as the acrid matter is commonly soluble in that fluid. Starch is usually associated with the acrid principle.

Arisæma atrorubens, Dragon-root, Indian Turnip. — From the tuber of this plant a nutritious fecula is obtained in the United States. The tuber is

Fig. 1064. *Fig.* 1065. *Fig.* 1066.

Fig. 1067.

Fig. 1064. A plant of the Cuckow-pint (*Arum maculatum*) in fruit. *b.* Underground corm or tuber. *l.* Leaf. *s.* The remains of the spathe. *c.* Fruit.——*Fig.* 1065. The spadix of the same with the spathe removed; the flowers are all naked and unisexual, the pistillate flowers being below, the staminate above, and those in the centre are abortive.——*Fig.* 1066. Vertical section of the pistil of the same.——*Fig.* 1067. Vertical section of the seed of ditto.

also given internally as a stimulant in rheumatism, bronchial affections, &c., and is also used extensively as an application to aphthous affections in children.

Arum.—The underground stems (tubers or corms) of some of the species of this genus, contain a large quantity of starch; those of *A. maculatum*, Wake-Robin, Cuckow-pint, or Lords and Ladies, a common native of this country, are the source of what has been called Portland Sago, or Arrow-root; 1 peck of tubers yields about 3lbs. of starch. The preparation of this starch is now almost, if not entirely, given up. Formerly the tubers were used medicinally as diuretics and expectorants. When fresh, they act as an irritant poison. *Arum campanulatum*, or *Amorphophallus campanulatus*, and *A. indicum*, produce edible corms.

Caladium bicolor.—The corms of this and other species, when cooked, are edible. They are sometimes, but improperly, called "Yams" in tropical countries. (See *Dioscorea* for true Yams.)

Colocasia esculenta and others, have large fleshy corms, which are much used in the West Indies, Madeira, &c., as food, under the names of Yams,

Cocoes, or Eddoes. *C. himalensis* has also edible corms. They are used for food in the Himalayas. *C. antiquorum* is applied to a like purpose in Egypt, and the corms of *C. macrorhiza* are eaten in the South Sea Islands under the name of Tara.

Natural Order 276. PISTIACEÆ or LEMNACEÆ.—The Duckweed Order (*figs.* 1068, 1069).—Floating aquatic plants (*fig.* 236), with lenticular or lobed leaves or fronds. *Flowers* 2 or 3, enclosed in a spathe (*fig.* 1068), monœcious, placed

Fig. 1068.

Fig. 1069.

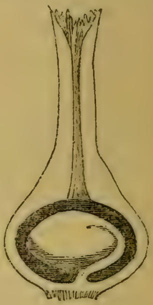


Fig. 1068. A monœcious head of flowers of a species of Duckweed (*Lemna minor*), consisting of two male flowers, each of which is composed of a solitary stamen with quadrilocular anthers; and one pistillate flower in the centre. The whole surrounded by a spathe.——*Fig.* 1069. Vertical section of the pistil of the same.

on the margin or surface of the frond (*fig.* 236), or in the axils of leaves. *Perianth* none. *Male flower* with 1 (*fig.* 1068), or a few stamens, which are often monadelphous. *Female flower* consisting of a 1-celled ovary (*fig.* 1069), with 1 or more erect ovules. *Fruit* 1- or more seeded, membranous or baccate, indehiscent, or sometimes dehiscent. *Embryo* straight, cleft, in the axis of fleshy albumen.

Distribution, &c.—They inhabit cool, temperate, and tropical regions. *Examples:*—Lemna, Pistia, Ambrosinia. There are 9 genera, and 20 species. Their properties are unimportant.

Natural Order 277. NAIADACEÆ.—The Pondweed Order. (*figs.* 1070—1073).—Aquatic plants with jointed cellular stems. *Leaves* with interpetiolar membranous stipules. *Flowers* small, unisexual (*figs.* 1070, 1071). *Perianth* either wanting, or composed of 2 or 4 parts. *Stamens* few, hypogynous; *pollen* globose. *Ovaries* 1 or more, superior (*fig.* 1071); *ovule* solitary (*fig.* 1072). *Fruit* 1-celled, 1-seeded (*fig.* 1073). *Seed* exalbuminous (*fig.* 1073); embryo with a lateral cleft.

Fig. 1070. *Fig.* 1071. *Fig.* 1072. *Fig.* 1073.

Fig. 1070. Two flowers of the Horned Pondweed (*Zannichellia palustris*), one staminate, the other pistillate.——*Fig.* 1071. The pistil of the same, composed of four perfect carpels, and one imperfect. —— *Fig.* 1072. Vertical section of the ovary of the same. *Fig.* 1073. Vertical section of the fruit and seed. All magnified. After Lindley.

Distribution, &c. — Chiefly found in extra-tropical regions. *Examples :* — Naias, Zannichellia. They have no known uses.

Natural Order 278. ZOSTERACEÆ.—The Sea-wrack Order.—*Diagnosis.* — This is a small order of marine plants with the habit of sea-weeds. They are usually associated with the Naiadaceæ, but from which they are principally distinguished by their filamentous or confervoid pollen, and also usually, by the complete absence of a perianth.

Distribution, &c. — They are widely distributed in the ocean in various quarters of the globe. *Examples :*— Amphibolis, Zostera. There are 5 genera, and 12 species. Their properties are of little importance. *Zostera marina*, Sea-wrack, is in common use for packing, and for stuffing chairs, mattrasses, &c., under the name of *Alva* (*Ulva* or *Alga*) *marina.*

Natural Order 279. TRIURIDACEÆ. —The Triuris Order. — *Diagnosis.* — This is a small order of plants closely allied to Naiadaceæ, but usually to be distinguished by its rudimentary embryo. The flowers are, however, sometimes perfect.

Distribution, &c. —Exclusively found in warm and tropical regions.— *Examples :* — Triuris, Sciaphila. There are 5 genera, and 8 species.

Their properties and uses are unknown.

Natural Order 280. HYDROCHARIDACEÆ.—The Hydrocharis or Frog-bit Order. — Aquatic plants. *Flowers* spathaceous, regular, diœcious or polygamous. *Perianth* superior, in 1

or 2 whorls, each of 3 pieces, the inner petaloid. *Stamens* few or numerous. *Ovary* inferior, 1—9-celled. *Fruit* indehiscent. *Seeds* numerous, without albumen.

Distribution, &c.—Inhabitants of fresh water in Europe, North America, East Indies, and New Holland. *Examples:*—Anacharis, Vallisneria, Stratiotes, Hydrocharis. There are about 16 genera, and 25 species. Their properties are unimportant.

Natural Order 281. RESTIACEÆ. —The Restio Order.—Herbs or under-shrubs. *Leaves* absent, or narrow. *Stems* either naked, or more commonly with slit equitant leaf-sheaths. *Flowers* with glumaceous bracts, spiked or aggregated, generally unisexual. No true perianth, its place being usually supplied by glumes. *Stamens* 2—3, adherent to 4—6 glumes, or the latter sometimes absent; *anthers* generally 1-celled. *Ovary* 1—3-celled, with 1 pendulous ovule in each cell. *Fruit* capsular or nut-like. *Seeds* albuminous, without hairs; *embryo* lenticular, and terminal.

Distribution, &c.—Natives principally of South Africa, South America, and Australia. None occur in Europe. *Examples:*—Leptocarpus, Willdenovia, Restio. There are 25 genera, and 171 species.

Properties and Uses. — Unimportant. The wiry stems of some species have been used for basket-making, &c., and for thatching.

Natural Order 282. ERIOCAULACEÆ. — The Eriocaulon or Pipewort Order.—Aquatic or marsh plants. *Leaves* clustered, linear, usually grass-like. *Flowers* minute, unisexual, in dense heads, each arising from the axil of a membranous bract. *Perianth* tubular, 2—3-toothed or lobed. *Stamens* 2—6; *anthers* 2-celled, introrse. *Ovary* superior, 2—3-celled. *Fruit* dehiscent, 2—3-celled, 2—3-seeded. *Seeds* pendulous, albuminous, hairy or winged; *embryo* lenticular, terminal.

Distribution, &c.—Mostly natives of tropical America, and the north of Australia. One species is found in Britain —*Eriocaulon septangulare*. There are 9 genera, and 200 species. Their properties are unimportant.

Natural Order 283. DESVAUXIACEÆ. — The Bristlewort Order.—Small sedge-like herbs, with setaceous sheathing leaves. *Flowers* glumaceous, enclosed in a spathe. *Glumes* 1 or 2. *Paleæ* none, or 1 or 2 scales parallel with the glumes. *Stamens* 1 or very rarely 2; *anthers* 1-celled. *Carpels* 1—18, distinct or more or less united, with 1 stigma and 1 pendulous ovule to each. *Fruit* composed of as many utricles as there are carpels. *Seeds* albuminous; *embryo* lenticular, terminal.

Distribution, &c.— Natives of Australia and the South Sea Islands. *Examples:* — Centrolopis (Desvauxia), Aphelia. Their properties and uses are unknown.

Sub-class III.—*Glumaceæ or Glumiferæ.*

Natural Order 284.—CYPERACEÆ.—The Sedge Order (*figs.* 1074—1079).—Grass-like or rush-like herbs (*fig.* 218). *Stems* solid, without joints or diaphragms, frequently angular (*fig.* 1074). *Leaves* with entire or closed tubular sheaths round the stem (*fig.* 1074). *Flowers* spiked, imbricated, perfect (*fig.* 1077), or unisexual (*figs.* 1075 and 1076), each arising from the axil of 1—3 bracts or glumes. The lowermost glumes are frequently empty or without flowers in their axils. *Perianth* absent, or existing in the female flowers in the form of a tube (perigynium)

Fig. 1074.

Fig. 1075.

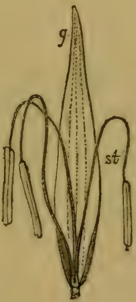


Fig. 1076.

Fig. 1074. A portion of the angular stem of a species of *Carex*, with entire sheath.——*Fig.* 1075. Staminate flower of a species of *Carex*. *st.* Stamens, with long filaments and pendulous innate anthers. *g.* Scale or glume.——*Fig.* 1076. Pistillate flower of a species of *Carex*, consisting of a glume at the base, and a pistil surrounded by an urn-shaped tube, *u.* (*Perigynium*), with a style, *st*, and three stigmas.

(*fig.* 1076, *u*), or as hypogynous scales or bristles (*fig.* 1077, *b*). *Stamens* hypogynous (*fig.* 1077), 1—12, commonly 3 (*figs.* 1075 and 1077); *anthers* 2-celled, innate (*figs.* 1075 and 1077). *Ovary* 1-celled, superior (*fig.* 1077), with 1 erect ovule. *Fruit* indehiscent, 1-seeded (*fig.* 1078). *Seed* with fleshy or mealy albumen (*fig.* 1078, *alb*); *embryo* lenticular (*figs.* 1078, *pl*, and 1079), enclosed in the base of the albumen (*fig.* 1078).

Distribution, &c.—Natives of all parts of the world, and found especially in marshes, ditches, and about running streams.

Fig. 1077. *Fig.* 1078. *Fig.* 1079.

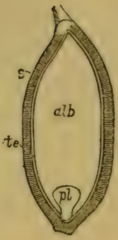


Fig. 1077. Hermaphrodite flower of a species of Club-rush (*Scirpus*), the glume having been removed. *b.* Hypogynous setæ or bristles forming a kind of perianth. *st.* Hypogynous stamens with 2-celled innate anthers. *o.* Ovary. *s.* Style. *stig.* Stigmas——*Fig.* 1078. Vertical section of the fruit of a *Carex*. *s.* Pericarp. *te.* Testa. *alb.* Albumen. *pl.* Embryo.——*Fig.* 1079. Embryo of a species of *Carex* removed from the albumen. *a.* Lateral swelling. *r.* Radicle. *c.* Cotyledon. *f.* Slit corresponding to the plumule.

Examples: — Carex, Elyna, Scleria, Rhyncospora. Schœnus, Cladium, Chrysithrix, Hypolytrum, Fuirena, Scirpus, Cyperus. Papyrus. There are 120 genera, and about 2000 species.

Properties and Uses. — Although closely allied in their botanical characters to the Graminaceæ, the Cyperaceæ are altogether deficient in the nutritive and other qualities which render the plants of that order so eminently serviceable to man and other animals. Indeed the order generally is remarkable for the absence of any important properties. Some are slightly aromatic, stomachic, and diaphoretic; others demulcent and alterative, and some have been used for economic purposes. The underground stems of certain species are edible when roasted or boiled.

Carex. —The creeping stems of *Carex arenaria* and some allied species have been used medicinally as substitutes for sarsaparilla, under the name of German Sarsaparilla.

Scirpus.—Various species of this genus, as *S. lacustris* and *S. Tabernæmontani*, *&c.*, are much employed like the common Rushes for mats, chair-bottoms, baskets, &c., and also by coopers for filling up intervals in the seams of casks. They are commonly known as Club-Rushes or Bull-Rushes. The root of *S. lacustris* was formerly used as an astringent and diuretic.

Eriophorum. — The species of this genus are commonly known under the name of Cotton-grasses, from their fruits being surrounded by cottony or downy hairs. These hairs are sometimes used for stuffing cushions, &c. The leaves are reputed to possess astringent properties.

Cyperus. — The rhizomes, tubers, or corms of *C. longus*, *C. rotundus*,

and *C. esculentus*, were formerly employed in medicine, and regarded as aromatic tonics, diaphoretics, and astringents. The corms of *C. esculentus* are also used as food in the South of Europe, and when roasted, have been proposed as a substitute for coffee and cocoa. The boiled corms of *C. bulbosus* are also edible, Royle says that they taste like potatoes. *C. textilis* is used for making ropes, &c., in India.

Papyrus.—P. antiquorum appears to be the Bulrush of the Nile. It is celebrated on account of the soft cellular substance in the interior of its stems, having been in common use by the ancients for making a kind of paper. The sheets of papyrus paper are remarkable for their durability. The Papyrus was also used for making ropes, boats, mats, &c. A Sicilian species, *P. sicula* has likewise been employed for making paper. *P. corymbosus* is extensively used in India for the manufacture of the celebrated Indian matting.

Natural Order 285.—Graminaceæ.—The Grass Order (*figs.* 1080—1086).—Herbs (*fig.* 1080), shrubs, or arborescent plants, with round, commonly hollow (*fig.* 187), jointed stems. *Leaves*

Fig. 1080.

Fig. 1081.

Fig. 1082.

Fig. 1080. A portion of the stem of the Cat's-tail Grass (*Phleum pratense*), bearing a leaf with parallel veins, and a split sheath.——*Fig.* 1081. Diagram of a spikelet of an Oat (*Avena*). (From Maout). *gl, gl.* two glumes, enclosing two perfect flowers, and one, *a*, abortive. *b.* the outer palea. *b, b.* the inner palea, which seems to be formed of two united. *p, p.* two scales (*squamulæ* or *glumellules*), the dotted curved line on the right marks the position of a third abortive scale. *e.* Stamens. *c.* Ovary.——*Fig.* 1082. A spikelet of the Oat (*Avena sativa*). *ge.* outer glume. *gi.* inner glume. *pe.* outer palea of the fertile flower. *pi.* inner palea of the same. *e.* Stamens. *o.* Ovary. *fa*, and *a*, abortive flowers.

alternate, with split sheaths (*figs.* 351 *g*, and 1080), and a ligule at the base of the lamina (*fig.* 351, *lig*). *Flowers* perfect or unisexual, arranged in spiked (*fig.* 395), panicled (*fig.* 396), or racemose locustæ or spikelets; or solitary. No true perianth, its place being supplied by imbricated bracts, of which there are commonly 2, called glumes, or rarely 1, at the base of the solitary flower, or at the base of each locusta (*figs.* 382 and 1081, *gl*, *gl*, and 1082, *ge*, *gi*). Occasionally the glumes are altogether absent. Each flower is also usually furnished with two other alternate bracts (*paleæ*) (*figs.* 1082, *pe*, *pi*, and 1084 and 1085), or sometimes the inner palea *p*, *i* is wanting; and 2 or 3 scales (*lodiculæ* or *glumellules*) (*figs.* 1081, *p*, *p*, and 1083, *p*), the latter also are sometimes wanting. *Stamens* 1—6 or more, frequently 3 (*figs.* 1083—1085); *filaments* capillary (*figs.* 490 and 1084); *anthers* versatile (*figs.* 490 and 586). *Ovary* superior (*fig.* 1083), 1-celled, with a solitary ascending ovule; *stigmas* feathery or hairy (*figs.* 586 and 1083). *Fruit* a caryopsis (*figs.* 686 and 687). *Seed* with mealy albumen (*fig.* 687, *a*), and a

Fig. 1083.

Fig. 1084.

Fig. 1085.

Fig. 1086.

Fig. 1083. Fertile flower of the Oat, without the paleæ. *p.* Glumellules. *c.* Stamens. *o.* Ovary. *s*, *s.* Feathery stigmas.——*Fig.* 1084. One of the florets of a species of Meadow Grass (*Poa pratensis*).——*Fig.* 1085. One of the florets of the Hard Fescue Grass (*Festuca duriuscula*).——*Fig.* 1086. The Embryo of the Oat. *a.* Lateral swelling. *c.* Cotyledon. *r.* Radicle. *f.* Slit corresponding to the plumule.

lenticular embryo (*figs.* 687 and 1086), lying on one side at the base of the albumen (*fig.* 687, *c*, *g*, *r*).

Distribution, &c.—Grasses are universally distributed over the globe. In temperate and cold climates they are herbaceous and of moderate height, while in tropical countries they become shrubby and arborescent, and sometimes grow to the height of

50 or 60 feet. Grasses usually grow together in large masses, and thus form the verdure of great tracts of soil ; and hence they have been termed social plants. *Examples:* — Oryza, Phalaris, Panicum, Paspalum, Stipa, Agrostis, Arundo, Gynerium, Pappophorum, Chloris, Avena, Festuca, Bambusa, Triticum, Secale, Hordeum, Ægylops, Rottbœllia, Saccharum, Andropogon. There are 300 genera, and probably about 3800 species.

Properties and Uses. — Of all the Orders in the Vegetable Kingdom this is the most important to man, as it affords his principal food, and is eminently serviceable in other respects, by supplying fodder for cattle, sugar, and other useful products. The native countries of our more important Cereals or Corn producing plants are altogether unknown. A few of the Grasses yield fragrant volatile oils. Almost all grasses are wholesome, but one or more species of *Bromus* have been reputed erroneously to be purgative, and one, *Lolium temulentum*, is said to be narcotic and poisonous. The powerful properties of the last grass would appear to be due to its becoming ergotised, as its described effects upon the system closely resemble those produced by the common ergot.

Oryza sativa is the Rice plant, the grain of which is more largely used for food than that of any other cereal. Starch of good quality, known as Jones' Patent Rice Starch, and Mechlin Glaze Starch, are largely prepared from rice. From 40 to 50 varieties of the Rice plant are known and cultivated. Rice appears to be less nutritive than the other cereal grains, and to be of a more binding nature, hence its use in diarrhœa, &c. Spirit is sometimes distilled from the fermented infusion of rice. This spirit is frequently called arrack, but that name is properly used only in reference to the spirit distilled from Palm wine.

Zizania aquatica yields a serviceable grain known as Canada Rice or Swamp Rice.

Zea Mays is the Indian Corn or Maize Plant. The grain is extensively used in warm countries. It is the most fattening of all the cereals, but it frequently produces diarrhœa. Maize meal is sold under the name of *polenta*. In South America a kind of beer, called Chica or Maize Beer is extensively used. In Western Africa, a favourite fermented beverage is also prepared from Maize, called *pitto* or *peto*.

Coix lachryma is remarkable for its hard stony fruits, which are used for beads. They are reputed to be diuretic. They are known as Job's tears.

Phalaris canariensis, Canary-grass, is cultivated for its grain, which is employed as a food for birds, under the name of canary seed. Its straw is also valued as a fodder for horses.

Holcus. — *H. saccharatus* or *Sorghum saccharatum*, is called the North China Sugar-cane or Sweet Sorgho. It is cultivated in China and other parts for the purpose of extracting its sugar. It is said to yield from 10 to 15 per cent. of sugar. Its grain is eaten in Africa, and is termed *Dochna*. The plant has been lately introduced into this country, and is highly recommended by some, for cultivation as a summer forage for cattle, but at present, our knowledge respecting it, will not allow of our drawing any positive conclusions upon its merits. *H. Sorghum*, *Sorghum vulgare*, or *Andropogon Sorghum*, of which there are several varieties, is extensively cultivated in Africa, India, &c., for the sake of its grain, which is known as Guinea Corn, Durra, Turkish Millet, and Jaar. This grain is much used as food in warm countries. In this country it has been employed for feeding poultry. The stalks are used in the manufacture of carpet-brooms, whisks, &c. A kind of beer called Bouza is prepared from the grains.

Paspalum exile yields the smallest known cereal grain. The grain is known on the West Coast of Africa, where it is used as food, under the name of Fundi or Fundungi. It is commonly called in Sierra Leone Millet. *P. scrobiculatum* also yields a kind of grain, known in India as the Menya or Kodro. A variety of this grass is reputed to be injurious to cattle.

Panicum miliaceum yields Indian Millet. The grain is called Warree and Kadi-kane, in the East Indies. *P. spectabile*, a Brazilian species, grows 6 or more feet in height. It is a favourite fodder grass, and is commonly known as the Angola grass. *P. jumentorum* is another fodder grass, called Guinea-grass. *P. pilosum* yields a grain known in India as Bhadlee. The grain of *P. frumentaceum* is also nutritious. It is termed Shamoola in the Deccan. Some of the Tartar tribes are said to prepare a kind of beer from Millet, which is called Bouza, Murwa, or Millet-beer, but this is probably prepared from a species of *Eleusine*. (See *Eleusine*.)

Setaria.—*S. germanica* is the source of German Millet, and *S. italica*, of Italian Millet. These are largely used as food.

Penicillaria spicata or *Panicum spicatum*, is called Caffre Corn. It yields a serviceable grain, which is commonly distinguished as African Millet.

Pennisetum dichotomum.—The grains of this grass are known in some parts of Western Africa under the name of *kasheia*. They are used there as food. In Egypt and Arabia, this grass is employed as fodder for camels, &c., and for thatching, &c.

Stipa. — *S. tenacissima*, a Spanish grass, was formerly used for various purposes under the name of *esparto*. It has been lately highly recommended as a substitute for rags in paper-making. The grain of *S. pennata*, Feather-grass, is said to be very nutritious.

Arundo Phragmites, the Common Reed. — The culms of this and some other species are much used for thatching and other useful purposes.

Gynerium argenteum is the elegant Pampas-grass. *G. saccharoides*, a Brazilian species, contains much sugar.

Eleusine coracana. — The grains of this plant constitute one of the Millets of India. In Sikkim, a kind of beer, called *murwa* or millet beer, is prepared from them, and is in general use by the natives. *E. Tocusso* is an Abyssinian plant. Its grain is used as food under the name of *Tocusso*.

Poa abyssinica is an Abyssinian corn plant, known under the name of *Teff*. The grains are sometimes employed in the preparation of Bouza or Millet beer.

Dactylis cæspitosa is the celebrated Tussac-grass of the Falkland Islands. It is an excellent fodder grass for cattle and horses. It is now grown to some extent in Shetland and other parts of Britain.

Bambusa arundinacea, the Bamboo. — The species of *Bambusa* are applied to many useful purposes in warm climates and elsewhere. Good paper is made from them. The very young shoots are boiled and eaten like Asparagus, and are also used for pickles and sweetmeats. Their hollow stems are variously employed. Dr. Hooker says, that in some districts "a very large kind of Bamboo is used for water-buckets, another for quivers, a third for flutes, a fourth for walking-sticks, a fifth for plaiting work (baskets), a sixth for arrows; while a larger sort serves for bows. The young shoots of one or more are eaten; and the seeds of another either raw or cooked, are made into a fermented drink. In China the Bamboo is used for numerous purposes — for water-pipes, fishing-rods, for making hats, shields, umbrellas, soles of shoes, baskets, ropes, paper, scaffolding-poles, trellis-work, sails, covers of boats, and Katamarans." The above extract will give some idea of the various uses to which the Bamboos are applied. A siliceous matter is commonly secreted at the joints of the Bamboo, to which the name of *tabasheer* has been given.

Avena sativa is the Common Oat. — A great number of varieties of this species are cultivated in the north of Europe, &c. on account of its grains, which are called Oats. They are extensively used as food for man and other animals. Oats deprived of their husk and coarsely ground form the *Oatmeal* of Scotland. When divested of their integuments, they are called *Groats;* and these when crushed, constitute *Embden* and *Prepared Groats*. Oats are also employed for the production of alcohol.

Triticum vulgare is the Common Wheat. — A great many varieties of *Triticum* are cultivated, as *T. æstivum*, Spring or Summer Wheat; *T. hybernum* Winter Wheat; *T. compositum*, Egyptian Wheat, or Many-eared Wheat;

T. Spelta, Spelt; *T. polonicum*, Polish Wheat, &c. Wheat is enormously used in this and some other countries in the manufacture of bread, and for its starch. Various nutritious foods are also prepared from wheat, as Semolina, Soujee, Manna Croup, Hard's Farinaceous Food, Vermicelli, Maccaroni, Cagliari or Italian Paste, &c.

Secale cereale, Common Rye, is much cultivated in the northern parts of the world for its grains, which are extensively employed for bread. Rye bread retains its freshness for a much longer time than wheaten bread. Quass or Rye Beer is a favourite drink in Russia. Rye is also used by the distillers. When roasted it has been employed as a substitute for coffee. Rye is subject to a disease called Ergot, produced by the attack of fungi (see *Cordyceps*), when its grains assume an elongated and curved form. The diseased grains are commonly known as Ergot of Rye or Spurred Rye, which in certain doses is poisonous to man and other animals. Medicinally, ergot is given to excite uterine contractions in labour, and for other purposes.

Hordeum, Barley. — Several species or varieties are commonly cultivated in cold and temperate climates for their grain; as *H. distichon*, Two-rowed or Long-eared Barley; *H. vulgare*, Bere, Bigg, Four-rowed or Spring Barley; *H. hexastichon*, Six-rowed Barley, and *H. zeocitron*, Sprat or Battledore Barley. Barley is used dietetically in the manufacture of bread, and in the form of malt, most extensively in the production of ale, beer, and ardent spirits. It is the common grain in use for the latter purposes in this country. Barley deprived of its husk, constitutes *Scotch*, *Hulled*, or *Pot Barley*. When both husk and integuments are removed, and the seeds rounded and polished, they form *Pearl Barley*, and this when ground is called *Patent Barley*.

Ægylops ovata. — This grass has lately become celebrated in consequence of M. Esprit Fabre having stated, that the varieties of cultivated Wheat were derived from it. This is not strictly correct, for the plants grown by M. Fabre, and the grains of which ultimately assumed the form of cultivated Wheat, were produced by hybridization between a species of *Triticum* and *Ægylops ovata*, the result being the formation of a variety of *Ægylops*, called *Ægylops triticoides*. The seeds of this by cultivation for about twelve years produce a grass-like ordinary wheat.

Saccharum officinarum is the Common Sugar-cane, so extensively used for the extraction of Cane-sugar. *Molasses* or *Golden Syrup* is the drainings from raw sugar, and treacle the thick juice which has drained from refined sugar in the sugar-moulds. *Caramel* is burnt sugar. *Sugar-candy*, *pulled sugar*, *barley-sugar*, *hard-bake*, *acidulated drops*, *&c.*, are all familiar preparations of sugar. By the distillation of the fermented liquid of treacle or molasses, rum is obtained.

Andropogon. — Several species of this genus are remarkable for their fragrance. This fragrance is due to the presence of volatile oils, of which several are used medicinally, and in perfumery. There is much uncertainty, however, as to the particular species which yield the different oils. The precious Spikenard Oil of Scripture is supposed by some to have been derived from *A. Iwarancusa*. The oil known in India as Roshé or Rosé Oil, and in London as Turkish Essence of Geranium, and *Oil of Geranium* or *Ginger-grass*, has been shown by Mr. Hanbury to be employed in Turkey to adulterate *Otto of Rose*. (See *Rosa*). It is also sometimes termed *oil of spikenard*. Its exact source is unknown, but it is certainly obtained from one or more species of Indian Andropogons. It is reputed to be the produce of *A. Calamus aromaticus*. This oil is also considered by some to be identical with the *grass-oil of Nemaur*. This plant is supposed by Royle to be the *sweet calamus* or *sweet cane* of the Bible. *A. citratum*, Indian Lemon Grass, is probably the source of the *oil of lemon-grass* of the shops. Oil of Lemon-grass is much employed in perfumery under the name of *oil of verbena*, from its odour resembling the Sweet Verbena or Lemon Plant of our gardens (*Aloysia citriodora*). The fresh leaves are sometimes used as a substitute for tea, and the centre of the stems for flavouring curries, &c. *Cetronelle* or *Citronelle* oil, is the produce of this or of an allied species of *Andropogon*. *A. muricatus*, Vittie-vayr or Cuscus, yields a fragrant oil according to Dr. Hooker, which is much used medicinally in India, unde the name of Kuskus oil. Its root is imported into this country, and used for scenting baskets, &c. Medicinally, it has been employed as a gentle stimulant, diaphoretic, antispasmodic, and diuretic.

Artificial Analysis of the Natural Orders of Monocotyledones. Modifiedfrom Lindley.

(The numbers refer to the respective Orders, as previously described.)

Sub-class I.—*Dictyogenæ.*

A. Ovary inferior.
  Flowers unisexual . . . . *Dioscoreaceæ.* 242.
B. Ovary superior.
  a. *Placentas basal* . . . . *Roxburghiaceæ.* 245.
  b. *Placentas axile.*
    Leaves whorled, not articulated . . . *Trilliaceæ.* 244.
    Leaves not whorled, articulated . . . *Smilaceæ.* 243.
  c. *Placentas parietal* . . . . *Philesiaceæ.* 246.

Sub-class II.—*Petaloideæ.*

1. Flowers with an evident Perianth.

A. Ovary inferior (*Epigynæ*).
  a. *Flowers gynandrous.*
    Ovary 1-celled. Placentas parietal . . . *Orchidaceæ.* 247.
    Ovary 3-celled. Placentas axile . . . *Apostasiaceæ.* 248.
  b. *Flowers not gynandrous.*
    1. Veins of leaves diverging from the midrib, and parallel to each other.
      Embryo enclosed in a vitellus.
        Anther 2-celled. Filament one, not petaloid *Zingiberaceæ.* 250.
      Embryo not enclosed in a vitellus.
        Anther 1-celled. Filament one . . . *Marantaceæ.* 251.
        Anther 2-celled. Filaments more than one *Musaceæ.* 252.
    2. Veins of leaves diverging from the base, and parallel to the midrib.
      Stamens 3.
        Anthers extrorse . . . . *Iridaceæ.* 253.
        Anthers introrse . . . . *Burmanniaceæ.* 249.
      Stamens 6.
        Anthers extrorse . . . . *Burmanniaceæ.* 249.
        Anthers introrse.
          Leaves equitant . . . . *Hæmodoraceæ.* 256.
          Leaves flat.
            Fruit 1-celled . . . . *Taccaceæ.* 257.
            Fruit 3-celled.
              Outer whorl of the perianth petaloid.
                Radicle next the hilum. Leaves not dry . . . . *Amaryllidaceæ.* 254.
                Radicle remote from the hilum. Leaves dry . . . . . . *Hypoxidaceæ.* 255.
              Outer whorl of the perianth not petaloid . . . . *Bromeliaceæ.* 258.
      Stamens more than 6 . . . . *Hydrocharidaceæ.* 280.
B. Ovary superior (*Hypogynæ*).
  a. *Outer whorl of the perianth herbaceous or glumaceous.*
    Carpels more or less distinct.
      Seeds attached over the whole inner walls of the fruit . . . . *Butomaceæ.* 272.
      Seeds attached to axile or basal placentas.
        Flowers conspicuous. Embryo curved, without a slit . . . . *Alismaceæ.* 271.
        Flowers inconspicuous. Embryo straight, with a lateral slit. . . . . . . *Juncaginaceæ.* 270.

Carpels combined into a solid pistil.
Inner whorl of the perianth different from the outer.
Placentas axile. Anthers 2-celled. Capsule 2—3-celled . . . . *Commelynaceæ.* 264.
Placentas parietal.
Anthers 2-celled. Capsule 1-celled . . *Xyridaceæ.* 265.
Anthers 1-celled. Capsule 1-celled . . *Mayaceæ.* 263.
The outer and inner whorls of the perianth alike.
Flowers on a spadix. Embryo with a lateral slit . . . . *Orontiaceæ.* 268.
Flowers not on a spadix. Embryo without a slit . . . . *Juncaceæ.* 267.
b. *Outer whorl of the perianth petaloid, or the whole petaloid when only one whorl is present.*
Carpels more or less distinct.
Seed solitary. Flowers on a spadix . . *Palmaceæ.* 269.
Seeds numerous. Flowers not on a spadix.
Anthers extrorse . . . . *Melanthaceæ.* 260.
Anthers introrse.
Perianth of 6 parts. Seeds without albumen . . . . *Butomaceæ.* 272.
Perianth of 2 parts. Seeds with albumen *Philydraceæ.* 266
Carpels combined into a solid pistil.
Perianth rolled inwards after flowering. Aquatics . . . . . . *Pontederaceæ.* 262.
Perianth not rolled inwards after flowering. Perianth minute, with coloured bracts externally . . . . . . *Gilliesiaceæ.* 261.
Perianth not rolled inwards after flowering, conspicuous, without coloured bracts . . . . *Liliaceæ.* 259.

2. Flowers either naked, or with a whorled scaly Perianth, generally unisexual (*Diclines*).

A. Flowers on a spadix.
a. *Flowers bisexual.*
Embryo cleft . . . . *Orontiaceæ.* 268.
Embryo solid . . . . *Pandanaceæ.* 273.
b. *Flowers unisexual.*
Embryo solid . . . . *Pandanaceæ.* 273.
Embryo cleft on one side.
Flowers with a true spathe. Fruit succulent.
Anthers sessile, or nearly so . . . . *Araceæ.* 275.
Flowers without a true spathe. Fruit dry.
Anthers on long filaments . . . . *Typhaceæ.* 274.
B. Flowers not arranged on an evident spadix.
a. *Flowers bisexual.*
Ovary superior . . . . *Juncaginaceæ.* 270.
Ovary inferior . . . . *Hydrocharidaceæ.* 280.
b. *Flowers unisexual.*
Ovules erect.
Embryo complete.
Seed without albumen . . . . . *Naiadaceæ.* 277.
Seed with albumen . . . . . . *Pistiaceæ.* 276.
Embryo rudimentary . . . . . . *Triuridaceæ.* 279.
Ovules pendulous.
Carpel solitary.
Seed without albumen.
Pollen globose . . . . *Naiadaceæ.* 277.
Pollen filamentous or confervoid . . . *Zosteraceæ.* 278.
Seed with albumen . . . . *Restiaceæ.* 281.
Carpels several, distinct.

Anthers 2-celled. Embryo cleft . . . *Naiadaceæ*. 277.
Anthers 1-celled. Embryo solid . . . *Desvauxiaceæ*. 283.
Carpels several combined.
Anthers 1-celled.
Stamens 2—3 . . . . *Restiaceæ*. 281.
Stamen 1. Ovary more than 2-celled . . *Desvauxiaceæ*. 283.
Anthers 2-celled. Placentas central.
Seeds with rows of hairs . . . . . *Eriocaulaceæ*. 282.
Seeds without rows of hairs . . . . . *Restiaceæ*. 281.
Anthers 2-celled. Placentas parietal . . *Xyridaceæ*. 265.

Sub-class III.—*Glumaceæ*.

Stem solid. Leaf-sheaths not slit. Embryo basilar within the albumen . . . . . . *Cyperaceæ*. 284.
Stem hollow. Leaf-sheaths slit. Embryo basilar outside the albumen . . . . *Graminaceæ*. 285.

SUB-KINGDOM II.

CRYPTOGAMIA, ACOTYLEDONES, OR FLOWERLESS PLANTS.

CLASS III. ACOTYLEDONES.

Sub-class I. *Acrogenæ.*

Natural Order 286. FILICES.—THE FERN ORDER.—*Herbs* with rhizomatous stems (*fig.* 158), or *arborescent plants* (*fig.* 159). *Leaves*, or *fronds* as they are commonly called, arising irregularly from the rhizome (*fig.* 158), or placed in tufts at the apex of the stem (*fig.* 159); almost always circinate in vernation (*figs.* 158, 159, and 273); simple or compound (*figs.* 158 and 782). *Fructification* consisting of sporangia (*figs.* 780 and 781), collected in heaps (*sori*) usually on the under surface or at the margin of the fronds, or rarely on the upper surface, or occasionally in a spiked manner on a simple or branched rachis (*fig.* 782); the *sori* are either naked (*fig.* 780), or covered by a membranous scale (*indusium*), (*fig.* 781). *Sporangia* stalked (*fig.* 783), or sessile, and either annulate (*fig.* 783), or exannulate. *Spores* enclosed in the sporangia (*fig.* 783). (For further particulars upon the fructification of Ferns, see pp. 368—371.)

Division of the Order, &c.—This order is commonly divided into three sub-orders, which are frequently regarded by botanists as separate orders.

These sub-orders are called Polypodieæ, Danæeæ, and Ophioglosseæ. Their distinctive characters are as follows:—

Sub-order 1. *Polypodieæ* or *Polypodiaceæ.* The Polypody Sub-order, or Ferns proper (*figs.* 780—783). Fronds circinate in vernation. Sporangia more or less annulate, collected in sori on the under surface or at the margin of the fronds; or arranged in a spiked manner on a simple or branched rachis. *Examples:*—Ceterach, Polypodium, Asplenium, Lastræa, Alsophila, Parkeria, Hymenophyllum, Mertensia, Schizæa, Osmunda.

Sub-order 2. *Danæeæ* or *Danæaceæ.* The Danæa Sub-order.—Fronds circinate in vernation, and all fertile. Sporangia arising from the surface, or imbedded in the under surface or back of the fronds, more or less united, exannulate. *Examples:*—Danæa, Marattia.

Sub-order 3. *Ophioglosseæ* or *Ophioglossaceæ.* The Adder's Tongue Sub-order (*fig.* 1087). Fronds not circinate in

Fig. 1087.

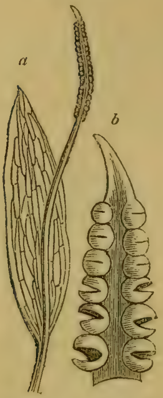


Fig. 1087, *a*, Barren and fertile fronds of the Common Adder's-tongue (*Ophioglossum vulgatum*): *b*, portion of the fertile frond of the same, with 2-valved, distinct, burst sporangia.

vernation, barren or fertile. Sporangia, arranged in a spike-like form (*fig.* 1087), on the margins of a contracted frond (*fig.* 1087, *b*), distinct, 2-valved (*fig.* 1087, *b*), exannulate. *Examples:* — Ophioglossum, Botrychium.

Distribution, &c. — The plants of this order are more or less distributed over the globe, but they are most abundant in moist, mild regions. In the northern hemisphere they are herbaceous plants, but in the southern hemisphere and in the tropics they are sometimes arborescent, having stems occasionally fifty feet or more in height, and with the general habit of Palms. There are about 210 genera, and upwards of 2000 species. The Polypodieæ alone contains about 200 genera.

Properties and Uses.— Several species of ferns have farinaceous rhizomes or stems, which, when roasted or boiled, form articles of food in certain parts of the world, but generally only in times of scarcity. The rhizomes of *Pteris esculenta*, *Diplazium esculentum*, *Nephrodium esculentum*, and *Marattia alata*, are those which are thus principally used. The leaves of several species possess slightly bitter, astringent, and aromatic properties, and those of others are mucilaginous. The rhizomes of certain ferns are astringent and tonic, and occasionally possess well-marked anthelmintic properties. The silky hairs found on the rhizomes and lower portions of the stalks of some species have been used for stuffing cushions, &c., and as mechanical styptics.

Acrostichum Huacsaro. — The rhizome of this species constitutes the middling Calaguala or Little Cord, which is used medicinally in Peru. (See *Polypodium.*)

Polypodium. — The rhizomes of *P. Calaguala*, Genuine or Slender Calaguala; of *P. crassifolium*, Thick Calaguala, or Deer's Tongue; and those of *Acrostichum Huacsaro* (see *Acrostichum*), are used medicinally in Peru, and are said to possess sudorific, diuretic, febrifugal, and anti-venereal properties.

Adiantum.—The fronds and rhizomes of *A. capillus Veneris*, True Maiden-hair, and those of *A. pedatum*, Canadian Maiden-hair, possess mucilaginous, bitter, slightly astringent, and aromatic properties, and have been employed as pectorals in catarrhs. The latter is most esteemed. Syrup of Capillaire is properly prepared, by adding to an infusion of Maiden-hair some sugar and orange-flower water. The fronds of *A. melanocaulon* are reputed to have tonic properties.

Pteris aquilina, the Common Brake, possesses anthelmintic properties.

Lastræa.—The rhizome and the thickened bases of the petioles of the fronds of *Lastræa* (*Nephrodium*) *Filix-mas* constitute the *fern root of the shops*, which

has been used from the earliest times as an anthelmintic. It possesses most activity in a recent state. The rhizome of *Lastræa* (*Aspidium*) *Athamanticum*, under the names of *Panna* and *Uncomocomo*, is also much esteemed by the Zoolu Caffres in Southern Africa as an anthelmintic.

Aspidium fragrans. — The fronds possess aromatic and slightly bitter properties, and have been used as a substitute for tea.

Cibotium. — The silky hairs covering the lower portion of the caudex of *C. Barometz*, the Scythian Lamb of old writers, have been imported under the name of *Penawar* or *Penghawar Jambie*. This drug has been used in Holland and Germany as a styptic. It has also been employed for stuffing cushions, &c. It is produced in Sumatra. Analogous hairs imported from the Sandwich Islands under the name of *Pulu*, may be employed for similar purposes as the preceding. Pulu is said to be derived from three species of *Cibotium*, viz. *C. glaucum*, *C. chamissoi*, and *C. Menziesii*. Other species produce somewhat similar hairs.

Balantium chrysotrichum. — The silky hairs found on the caudex of this fern may be employed in like cases to the preceding. They are imported under the name of *Pakoe Kidang*, from Java. *B. Culcita* and other species, as well as some other allied ferns, produce analogous hairs.

Ophioglossum vulgatum, the Common Adder's-tongue, has been employed as a vulnerary. In some districts it is used in the preparation of a popular ointment.

Natural Order 287. EQUISETACEÆ.—THE HORSETAIL ORDER. —*Herbaceous plants*, with striated, hollow, jointed, simple or verticillately branched, aerial, siliceous stems, arising from slender creeping rhizomes or underground stems. The *joints* are surrounded by membranous toothed sheaths, which are regarded by some botanists as modified leaves, but in general the plants of the order are considered *leafless*. When branched, the branches arise in a whorled manner from beneath the axils of the teeth of the sheaths and correspond in number with them. *Stems* barren or fertile. *Fructification* borne in cone-like or club-shaped masses at the termination of the stem (*fig.* 157). Each mass is composed of peltate scales bearing numerous sporangia on their under surface (*fig.* 787), which dehisce internally by a longitudinal fissure. *Spores* surrounded by elastic club-shaped elaters (*figs.* 788 and 789). (See page 371 for a more detailed account of the fructification.)

Distribution, &c. — These plants are found in marshy or watery places in most parts of the world. There is but 1 genus (*Equisetum*), which includes about 10 species, the greater number of which are indigenous.

Properties and Uses.—Of little importance either in a medical or economic point of view. They were formerly regarded as slightly astringent, diuretic, and emmenagogue, but are never employed at the present day. The rhizomes contain a good deal of starchy matters in the winter months, and might therefore, in case of need, be used as food, like those of ferns. Silex is abundant in their epidermal tissues; this is especially the case in *Equisetum hyemale*, Rough Horse-tail, which is largely imported from Holland under the name of Dutch Rushes, and employed by cabinet makers, ivory turners, white smiths, &c., for smoothing the surface of their work.

Natural Order 288. Marsileaceæ.—The Pepperwort Order. —*Aquatic herbs*, with small floating or creeping stems (*fig.* 1088), from which arise sessile (*fig.* 1088), or stalked leaves (*fig.* 343).

Fig. 1088.

Fig. 1088. The Creeping Pill-wort (*Pilularia globulifera*). The stems are creeping, and bear numerous sessile leaves, which are circinate in vernation. The sporocarps are downy, and placed in the axils of the leaves.

Fig. 1089.

Fig. 1089. *Lycopodium inundatum*, Marsh Club-Moss. The stem is creeping, and bears numerous small, sessile, imbricated leaves.

Leaves with circinate vernation (*fig.* 1088). *Fructification* at the bases of the leaves or petioles (*fig.* 1088), and consisting of stalked valvular sporocarps (*figs.* 790, 793, and 794), enclosing antheridia (*fig.* 791) and sporangia (*fig.* 792), which are either contained in the same cavity (*fig.* 790) or in separate sacs (*fig.* 794). (See pages 372—374.)

Distribution, &c. — They are widely distributed, but are most abundant in temperate regions. *Examples:*—Pilularia, Marsilea. There are 4 genera and about 20 species.

Properties and Uses. — Unknown, or of little importance.

Natural Order 289. Lycopodiaceæ.—The Club-moss Order. —Herbaceous plants, usually resembling Mosses, with creeping stems (*fig.* 1089) and forked ramification (*fig.* 156); or aquatic plants with corm-like stems (*fig.* 1090). *Leaves* sessile, usually

Fig. 1090.

Fig. 1090. *Isoëtes lacustris*, Lake Quill-wort. The stem is small and corm-like, and bears its leaves, which are linear-cylindrical, in tufts.

small and imbricated (*fig.* 1089), sometimes tufted (*fig.* 1090), and linear-cylindrical. *Fructification* in the axils of leaves (*figs.* 795 and 796), or immersed in their substance, often spicate

(*fig.* 156): consisting of either one kind of sporangium called the pollen-sporangium; or commonly of two, called oosporangia (*fig.* 798), and pollen-sporangia (*figs.* 796 and 797). The *pollen-sporangia* (*fig.* 797) contain a number of small spores (*microspores*); and the *oosporangia* enclose 4 large spores (*macrospores*) (*fig.* 798). (See pages 374, 375.)

Distribution, &c.—They are almost universally diffused, occurring in cold, temperate, and warm climates. *Examples:*—Lycopodium, Selaginella, Isoëtes. There are 6 genera, and about 200 species.

Properties and Uses.—Many species contain an acrid principle. In moderate doses they are frequently emetic and purgative, but in large doses they sometimes produce poisonous effects. Some are reputed to possess aphrodisiac properties. The spores are inflammable.

Lycopodium.—*L. clavatum*, the Common Club-moss, possesses well-marked emetic and purgative properties, and is reputed diuretic and emmenagogue. The spores have been employed externally, for their absorbent qualities, in erysipelas, and various cutaneous affections; and internally, they are said to be diuretic, sedative, and demulcent. These spores are of a yellow colour, and are sometimes known as *vegetable sulphur*. Besides their use in medicine as alluded to above, they are employed in pharmacy for covering pills, the object sought being, to render them tasteless and prevent their adherlng together. Lycopodium spores, however, from their inflammable nature, are principally used in the preparation of fire-works, and for the production of artificial lightning at the theatres, &c. *L. Selago* has similar medicinal properties, but it sometimes acts as a narcotico-acrid poison. The spores are of a like nature to those just noticed. *L. catharticum* is said to be a powerful purgative.

Natural Order 290. Musci. — The Moss Order. — Cellular plants (*figs.* 154, 155, and 802), terrestrial or aquatic, with erect or creeping stems, and usually spirally imbricated leaves. *Reproductive organs* of two kinds, called antheridia and archegonia. (See pages 375—378), which are either placed on the same, or on separate plants (*figs.* 154 and 155). The *antheridium* (*fig.* 799) is a more or less rounded, elliptic, or cylindrical sac, containing when mature, a number of cells (*zoothecæ*), each of which encloses a spirally twisted filament (*phytozoon*). The *archegonium* is usually a flask-shaped body (*fig.* 800), which after fertilization developes an urn-shaped sporangium (*figs.* 803 and 804) with a central columella (*fig.* 807); the space between which and the walls of the sporangium being occupied by spores, without any elaters among them. The *sporangium* is commonly placed on a stalk (*seta*) (*figs.* 801, *t*, and 802, *p*), and at first is covered by a hood (*calyptra*) (*figs.* 802 and 803 *c*), beneath which is a kind of lid (*operculum*) (*figs.* 804, *o*, and 805). The sporangium usually opens when ripe in a transverse manner from the separation of the operculum (*fig.* 805); or sometimes by splitting vertically into four equal valves, which are connected at the summit by the persistent operculum (*fig.* 1091, *a*); or rarely irregularly. At the de-

hiscence of the sporangium, its mouth (*stoma*) is seen to be either fringed by one or two-rows of teeth (*peristome*) (*fig.* 804, *p*), or naked (*gymnostomous*) (*fig.* 805).

Division of the Order, &c.—This order is usually separated into two divisions, which are frequently regarded as distinct orders. The principal distinctive characters of the two divisions are as follows :—

Fig. 1091.

Fig. 1091. A portion of *Andræa rupestris*, much magnified. The stem is erect, with numerous small imbricated leaves, and a terminal sporangium, which is destitute of a seta. *a*, sporangium after dehiscence, showing the 4 equal valves of which it is composed connected at the summit by the persistent operculum. The valves are seen to have dehisced vertically. After Hooker.

Sub-Order 1. *Bryaceæ* or *Bryeæ.*—Urn-Mosses.—Sporangium dehiscing transversely by the separation of the operculum, or irregularly. *Examples :*—Pottia, Splachnum, Wardia, Bryum Funaria, Polytrichum, Hypnum, Neckera, Hookeria, Sphagnum. The genus Sphagnum is by Henfrey, made to constitute a distinct order, under the name of Sphagnaceæ or Bog-mosses; these are principally distinguished from the Bryaceæ in habit, and in the curious structure of their leaves.

Sub-Order 2. *Andræaceæ* or *Andræeæ.*—Split-Mosses.—Sporangium splitting vertically into 4 valves which are connected at the summit. *Examples :*—Andræa, Acroschisma. These are the only genera in this sub-order.

Distribution, &c.—They are generally diffused over the globe, but most abundantly in temperate climates. There are 46 genera, and about 1200 species.

Properties and Uses.—Of little importance either in a medical or economic point of view. Some species possess astringent and diuretic properties, but they are not used in medicine. The species of *Sphagnum* furnish food to the reindeer, and even to man in the polar regions.

Natural Order 291. Hepaticaceæ.—The Liverwort Order.—(See pages 378—381.) Small cellular plants, either with a creeping stem bearing minute imbricated leaves (*fig.* 1092), or with a lobed leaf-like frond or thalloid expansion (*figs.* 808 and 810). *Reproductive organs* of two kinds, called respectively, antheridia and archegonia, which are either on the same plant or on different ones. The *antheridia* are small, oval, globular, or flask-shaped (*fig.* 809,) cellular sacs, situated in the axils of leaves, or immersed in the frond, or imbedded in the upper surface of peltate or discoid-stalked receptacles (*fig.* 808). The

archegonia (*fig.* 811), are usually somewhat flask-shaped bodies, which are imbedded in the fronds, or contained in receptacles (*fig.* 810, *r*) elevated on stalks above the thallus. Each archegonium developes after fertilization a sporangium, which either bursts by valves (*fig.* 1093), or by teeth, or by irregular fissures. The *sporangium* is usually without a columella, and contains spores mixed with elaters (*fig.* 812); or it is furnished with a thread-like columella, and contains spores and no elaters, or the latter are imperfect; or it has neither elaters or columella.

Fig. 1092.

Fig. 1093.

Fig. 1092. *Jungermannia bidentata.* The stem is creeping, and bears numerous small imbricated leaves. ——*Fig.* 1093. Sporangium of *Jungermannia hyalina*, dehiscing vertically by 4 valves, and containing spores in its interior.

Division of the Order, &c. — This order may be divided as follows: —

Sub-order 1. *Jungermanniaceæ* or *Jungermanneæ.* — Scale-Mosses (*figs.* 1092 and 1093). — Sporangia oval; without a columella; splitting vertically by 4 valves (*fig.* 1093). Spores mixed with elaters. *Examples:* — Blasia, Hollia, Jungermannia, Sarcoscyphus.

Sub-order 2. *Anthoceroteæ.* —Sporangia pod-shaped; 1—2-valved; with a filiform columella. Spores either mixed with imperfect elaters, or these are absent. *Examples:* — Anthoceros, Monoclea.

Sub-order 3. *Marchantiaceæ* or *Marchanteæ.* — Liverworts (*figs.* 808—812).—Sporangia without valves; bursting irregularly or by teeth; without a columella. Spores mixed with elaters (*fig.* 812). *Examples:* —Fimbriaria, Marchantia.

Sub-order 4. *Ricciaceæ* or *Ricciеæ*.— Crystalworts.— Sporangia without valves; bursting irregularly; without a columella. Spores not mixed with elaters. *Examples:*—Riccia, Sphærocarpus.

Distribution, &c. —The plants of this order are generally diffused over the globe, but they are most abundant in damp shady places in tropical climates. There are about 65 genera, and 700 species.

Properties and Uses.—Of no importance. Some have been used in liver complaints, and *Marchantia hemispherica* and other species have been employed in the form of poultices, in dropsy.

Natural Order 292. CHARACEÆ. — The Chara Order. — *Water plants*, with a distinct stem, branching in a whorled manner (*fig.* 1094), and either transparent or coated with carbonate of lime. *Reproductive organs* of two kinds, arising at the base of the branches (*fig.* 813), and either on the same or on different branches of the same plant, or on separate plants. These organs are termed *globules* (*figs.* 813, *g*, 814, and 815), and *nucules* (*figs.* 813,*n*, 816, and 817). (See pages 381 and 382 for a detailed account of their structure.)

Distribution, &c. — The plants of this order occur in stagnant fresh or salt water in all parts of the globe; but they are most abundant in temperate climates. *Examples:*— There are two genera, Chara and Nitella, and 35 species.

Properties and Uses.—These plants give off a very fœtid odour when in a state of decay, which is regarded as very injurious to animal life. They have no known uses.

Fig. 1094.

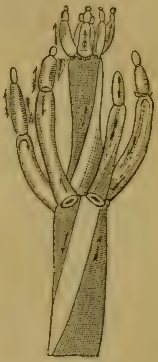


Fig. 1094. A small portion of a species of *Chara*, magnified. The branches are arranged in a whorled manner. In the interior of each cell the fluid matters with the contained granules exhibit a kind of circulation. The direction of the circulation is indicated by the arrows. The circulating matter does not pass from cell to cell, but is confined to that in which it originates.

Artificial Analysis of the Natural Orders in the Sub-class ACROGENÆ.

(The numbers refer to the Orders.)

1. With a distinct axis or stem.
   A. *Leafy plants.*
   a. Sporangia on the back or margin of the fronds or leaves, or on metamorphosed leaves . . *Filices.* 286.

b. Sporangia arranged in or near the axils of leaves or bracts, or immersed in their substance.
  1. Not enclosed in sporocarps.
    Sporangia sessile, without a calyptra . . *Lycopodiaceæ.* 289.
    Sporangia sessile, with a calyptra . . *Musci.* 290.
    Sporangia stalked, with a calyptra . . *Musci.* 290.
  2. Enclosed in sporocarps.
    Vernation circinate.
      Spores not mixed with elaters . . . *Marsileaceæ.* 288.
    Vernation not circinate.
      Spores mixed with elaters . . . *Hepaticaceæ.* 291.

B. *Leafless plants.*
  Stem simple, or with whorled branches.
    Fructification terminal, in club-shaped or cone-like masses . . . . . . *Equisetaceæ.* 287.
  Stem always branched in a whorled manner.
    Fructification at the base of the branches . *Characeæ.* 292.
2. With no distinct stem or axis.
  No true leaves, but forming a green thalloid expansion . . . . *Hepaticaceæ.* 291.

Sub-class II. *Thallogenæ.*

Natural Order 293. Lichenes.—The Lichen Order.—Perennial plants, composed of parenchymatous cells, arranged so as to form a foliaceous, somewhat woody, scaly, crustaceous, or leprous thallus ; living and fructifying in the air, and growing on the bark of trees, or on old palings, walls, &c., or on stones, or on the exposed surface of rocks; usually epiphytic, but sometimes parasitic, and commonly presenting a dry, shrivelled, more or less lifeless appearance. *Reproduction* either *vegetative* by *gonidia* (see page 385); or by true *fructification*, consisting of 1. *apothecia*, which are either sessile or stalked, and commonly of a rounded (*fig.* 819), or linear form (*fig.* 818), and composed of *asci* or *thecæ* (*figs.* 820 and 821), enclosing 4, 8, 16, or numerous spores; 2. of *spermagonia* containing *spermatia* (*figs.* 822 and 823); and 3. of rarely, *pycnidia* with stylospores. (For detailed account of the fructification of lichens, see pages 382—385.)

Distribution, &c.—Lichens are distributed in all parts of the world. The pulverulent species " are the first plants that clothe the bare rocks of newly formed islands in the midst of the ocean, foliaceous lichens follow these, and then Mosses and Liverworts." They also form a considerable proportion of the vegetation of the polar regions and of mountain-tops. *Examples:* —Pulveraria, Opegrapha, Verrucaria, Endocarpon, Lecidea, Cladonia, Peltigera, Usnea. According to Fée, there are 2400 species.

Properties and Uses. — Several lichens possess nutritive properties from containing amylaceous substances, such are also emollient and demulcent; others contain bitter principles, which render them tonic and astringent; and several are

important as dyeing agents. (See Dr. Lauder Lindsay's papers on Lichens, in Transactions of the Royal Society of Edinburgh.) A few possess aromatic properties. Some lichens, as species of *Variolaria*, contain a large amount of oxalate of lime. None are known to be poisonous.

Gyrophora.—Several species, denominated *tripe de roche*, possess nutritive properties, and are used as food in the arctic regions. Franklin and his companions owed their preservation in 1821, in a great measure, to the use of these lichens as food. The *Gyrophoras* also possess slight tonic properties, owing to the presence of a bitter principle. *G. pustulata* is one of the lichens used in this country by the manufacturers of orchil and cudbear. (See *Roccella.*) It may be also made to produce a brown colour.

Cladonia or *Cenomyce.*— *C. rangiferina* is the Reindeer Moss. It is so termed, from constituting the food, especially in the winter months, of the Reindeer. *Cladonia pyxidata*, or *Scyphophorus pyxidata*, is commonly termed Cup-moss; this and other species, have been employed as remedies in hooping-cough.

Parmelia parietina, was formerly regarded as a valuable febrifuge, astringent, and tonic. It contains a yellow, crystalline, colouring matter, called *chrysophanic acid*, which is identical with the yellow colouring principle of rhubarb. *P. perlata* is employed by the manufacturers of orchil and cudbear. (See *Roccella.*)

Variolaria. *V. dealbata* and *V. orcina*, are used for the production of orchil in France.

Lecanora.—*L. tartarea*, was formerly the principal lichen used in the preparation of the dye called Cudbear. Cudbear is, however, now obtained, not only from it, but also from a number of other Lichens, as the species of *Roccella*, &c. (See *Roccella.*) *L. Perella* yields a similar dye. Two species of *Lecanora*, namely, *L. esculenta* and *affinis*, form important articles of food both to man and other animals in Persia, Armenia, Tartary, &c. They appear in some seasons in such enormous quantities, that in certain districts they cover the ground to the depth of several inches, and the natives believe that they fall from heaven. *L. esculenta* is also found in Algeria, Asia Minor, &c., and Dr. O'Rorke, in a recent communication, has endeavoured to prove that this substance was the *true manna of the Hebrews*,—that which fed them with regularity for forty years in the wilderness.

Sticta pulmonaria. Tree Lung-wort, Oak-lungs.—This lichen possesses tonic and nutritious properties, resembling in these respects, the *Cetraria islandicus.* In Siberia, it is used instead of hops for imparting bitterness to beer. It is also employed in France, &c. for the production of a brown dye.

Peltigera or *Peltidea canina*, and *P. rufescens* are known in the herb shops of this country under the name of Ground Liverwort. This was formerly officinal in the London Pharmacopœia, and regarded as a specific in hydrophobia.

Cetraria islandica. Iceland moss.— This lichen contains two kinds of starchy matters—one called *lichen starch*, and the other *inulin;* it also contains a bitter principle (*cetrarin*). It is officinal in our pharmacopœia and is employed as a nutritious food, and as a mild mucilaginous tonic in catarrh, consumption, &c. When used for food only, it should be previously deprived of its bitterness ; this may be done, either by heating it twice in water to near the boiling point of Fahrenheit, or by digesting it in a weak alkaline solution formed by adding half an ounce of carbonate of potash to about a gallon of cold water, and afterwards washing it with water. *C. nivalis* possesses somewhat similar properties.

Roccella. Orchella Weeds.— *R. fuciformis, tinctoria, hypomecha, flaccida?* and their varieties, under the common name of Orchella Weed, are the species commonly met with in this country. They are imported from various parts of the world, as the Canary and Cape de Verd Islands, the Azores, Angola, Madagascar, Mauritius, Madeira, South America, Cape of Good Hope, &c. In commerce they receive the name of the country from whence they have been derived. Orchella weed is extensively used in this country and elsewhere in the manufacture of purple and red colours, called *orchil* or *archil*, and *cudbear.* In Holland a blue colour, called *litmus*, is also prepared from the same lichens. Other lichens, as species of *Lecanora*, *Gyrophora*, *Par-*

melia, *Variolaria*, *&c.*, are also sometimes employed in Britain and elsewhere in the manufacture of orchil. (See these species above.) Orchil and cudbear are used for staining and dyeing purple and red colours, and also occasionally as tests for acids and alkalies. Litmus is employed as a test for alkalies, acids, and some salts with a basic reaction. A decoction of orchella weed possesses mucilaginous, emollient, and demulcent properties, and has been used in coughs, catarrhs, &c.

Natural Order 294. FUNGI. — The Mushroom Order. — Parenchymatous cellular plants, producing their fructification in the air; growing in or upon decaying or living organic substances, and nourished through their vegetative structure called the spawn or mycelium. (See page 385, and *figs.* 150—152, and 824). *Fructification* various. (See pages 385—388, and *figs.* 824—827.)

Distribution, &c. — They abound in all parts of the world. *Examples:* — Agaricus, Polyporus, Hydnum, Phallus, Lycoperdon, Bovista, Torula, Puccinia, Uredo, Botrytis, Morchella Peziza, Tuber, Sphœria, Mucor. The number of species is estimated at about 4000.

Properties and Uses.—Fungi have very variable properties. Some are medicinal, others edible, and others are deadly poisons. Many deaths have occurred from poisonous fungi having been mistaken for edible ones, and science as yet affords no certain characters by which they may be distinguished; some general characters, however, will enable us in most cases to do so; these may be tabulated as follows: —

Edible Mushrooms.

1. Grow solitary, in dry airy places.
2. Generally white or brownish.
3. Have a compact brittle flesh.
4. Do not change colour when cut by the action of the air
5. Juice watery.
6. Odour agreeable.
7. Taste not bitter, acrid, salt, or astringent.

Poisonous Mushrooms.

1. Grow in clusters, in woods, and dark damp places.
2. Usually with bright colours.
3. Flesh tough, soft, and watery.
4. Acquire a brown, green, or blue tint, when cut and exposed to the air.
5. Juice often milky.
6. Odour commonly powerful and disagreeable.
7. Have an acrid, astringent, acid, salt, or bitter taste.

We should, moreover, avoid all fungi which insects will not touch; and those which have scales or spots on their surface; and whatever may be the apparent qualities of the fungi, we should use with caution all which have arrived at their full development, or when they exhibit any signs of change. When we are doubtful as to the qualities of the mushrooms, it is very advisable to cut them into slices, and macerate them in vinegar

and water for about an hour, then wash them in boiling water previous to their being cooked. It has been proved that many injurious fungi lose their poisonous properties, when thus treated. It is quite true, that by following strictly the above rules, we shall sometimes throw aside edible species, but this is of little consequence, as by so doing we shall be certain to reject all injurious ones. The species or varieties of fungi commonly consumed in this country, are, the Common Mushroom (*Agaricus campestis*) and its varieties, those which are cultivated should be preferred; *Agaricus arvensis*, *Agaricus Georgii*, *Agaricus oreades*, the Champignon, which is used on account of its savoury qualities; *Morchella esculenta*, the Morel, and *Tuber cibarium*, the Truffle, and other species of the same genus. Dr. Badham believes, that much valuable food is thrown away in this country by our rejection of many edible fungi. He enumerates no less than 30 species of edible fungi which are natives of Britain, and which are eaten by himself and friends. In France, Russia, &c. several fungi are also eaten which are regarded by us as poisonous. It is difficult to account for these conflicting statements about the fungi; but we believe that the differences observed in their effects, are due to differences of soil and climate, manner of cooking, and the peculiar idiosyncrasies of individuals who partake of them. Even the Common Mushroom is sometimes poisonous, and in Italy, Hungary, &c. is commonly avoided. We believe, therefore, that with our present knowledge, it is far better to abstain altogether from fungi, when there exists the slightest doubt of their qualities.

In a chemical point of view, the fungi are remarkable for the large proportion of water which enters into their composition, by containing much nitrogen, and being rich in phosphates.

Medicinally, fungi have been regarded as aphrodisiac, narcotic, tonic, astringent, emetic, purgative, &c. Ergot of rye (see *Secale cereale*, p. 699), which is used medicinally, to excite uterine contractions in labour, and for other purposes, is now regarded by Berkley and others, as merely a transitional form, or rather the first stage in the existence of a peculiar fungus.

Fungi are frequently very destructive to living plants and animals, by growing upon them. Thus, in plants, the diseases known as blight, mildew, rust, smut, vine-mildew, potato-disease, ergot, &c., are either caused by, or accelerated by the agency of fungi. Fungi are associated with several cutaneous and other diseases of the human subject. The disease in the silkworm, known under the name of *muscardine*, is produced by one or more species of *Botrytis*. Similar diseases also occur in other animals. Caterpillars are frequently attacked by species of *Sphæria* or *Cordyceps*, in China, Australia, New Zealand, &c. and ultimately destroyed. The mucous membrane of birds, &c. is also commonly infested with fungi of various kinds. The

disease called *Dry Rot*, which occurs in wood, is especially caused by dampness, and the subsequent development of the spores of fungi, as those of *Merulius lacrymans* and *vastator*, and *Polyporus destructor*, *&c.* The different kinds of Moulds which are found on bread, cheese, preserves, fruits, paper, books, &c. are fungi of the species Mucor, Botrytis, Aspergillus, Penicillium, Oidium, &c. The following fungi require a more particular notice :—

Agaricus.—Agaricus campestris, the Common Mushroom (*figs.* 824 and 825) and its varieties; *A Georgii*, *A. arvensis*, *A. oreades*, the Champignon, *A. deliciosus*, and *A. procerus*, *&c.*, are largely used for food in this and other parts of the world. The subterranean mycelium of various species of *Agaricus*, as that of *A. oreades*, *prunulus*, *Orcella*, *campestris*, *&c.*, and that of allied genera, developes in a radiating manner, and, by the remains acting subsequently as a manure, causes the grass in our meadows, in such places, to grow in a very luxuriant manner in rings, whch are commonly called fairy rings.

Amanita muscaria is a very poisonous species. It possesses narcotic and intoxicating properties, and is much used in Kamtschatka and some other parts of the Russian empire, as a narcotic and intoxicating agent. It possesses the remarkable property of imparting its intoxicating effects to the fluid excretions of those who partake of it. This fungus, when steeped in milk, &c., acts as a poison to flies ; hence its specific name.

Boletus edulis is an edible fungus, which is much esteemed in Italy, &c.

Cyttaria Darwinii and *Berteroi* are also employed for food, the former in Terra del Fuego, and the latter in Chili.

Lycoperdon, the Puffballs.—When the *Lycoperdon giganteum* is submitted to combustion, the volatile emanations arising from it possess a narcotic property. It has been employed in this way to stupify bees when removing honey from the hive, and has been also recommended as an anæsthetic agent instead of chloroform. A similar property is also possessed by some other species.

Merulius lacrymans and *vastator* are two of the Fungi which occur in the disease called Dry Rot. (See above.)

Polyporus.—P. destructor is one of the Fungi found in the Dry Rot of wood. (See *Merulius*.) Thin slices of *P. igniarius* and *fomentarius*, when softened by beating with a mallet, are sometimes employed externally to restrain hæmorrhage. Similarly prepared slices, soaked in a solution of nitre, and dried, constitute *Amadou* or *German tinder*. When impregnated also with gunpowder, it forms *black amadou*. Amadou has been sometimes used to give support and pressure in certain surgical affections, and as a moxa. *P. squamosus*. and *betulinus*, when pressed, sliced, and prepared by rubbing with pumice, &c., are used to make razor strops. *P. officinalis*, Larch or White Agaric, has been employed externally as an astringent; and internally, to check perspiration, and as an emetic, cathartic, &c.

Tuber, the Truffle.—The species of Truffle, several of which occur in Britain, are subterranean. They are highly esteemed as seasoning or flavouring agents. The best are imported from France, Algeria, and Italy, preserved commonly in oil. *T. æstivum*, *cibarium*, *melanosporum* are the more frequently used species.

Mylitta australis is called Native Bread in Australia, where it is much used as food by the natives. It frequently weighs from one to three pounds. One or more species, nearly allied to *Mylitta australis*, are also used in China for food and as medicines.

Pachyma Cocos, Fries, is another fungus, allied to *Mylitta*, which is highly esteemed as a food and medicine by the natives of China, &c., and the Indians of the United States of North America. It is the Tuckahoe or Indian Bread of the United States.

Elaphomyces granulatus and *muricatus* are sold in Covent Garden Market under the name of Lycoperdon Nuts. They are supposed to possess aphrodisiac properties, and to promote parturition, and the secretion of milk.

Morchella esculenta, the Morel, is a highly esteemed edible fungus, which

is principally employed for flavouring. It is imported in a dry state from the Continent.

Exidia Auricula Judæ, Jew's Ear, is reputed to possess astringent and discutient properties, when applied externally in the form of a decoction, poultice, &c. *E. hispidula* is used in China as a styptic, and as a food mixed in soups, &c. It is known there under the name of Moghi, signifying ears of trees.

Cordyceps (*Sphæria*).—The disease called Ergot, which occurs in the grains of Rye and other grasses, is produced by *Cordyceps purpurea*. (See *Properties and Uses of Fungi.*) *C. Robertsii*, *sinensis*, *entomorrhiza*, and other species, frequently attack caterpillars in a living state, which they destroy as their mycelium developes. The remains of the caterpillar with the developed fungus of *C. sinensis*, is a highly esteemed drug in China, where it is much used as a tonic.

Uredo.—The species of this genus produce the diseases of Corn and other cultivated plants, called blights, rusts, &c.

Puccinia graminis is the fungus which produces the Mildew of Wheat.

Oidium.—The Vine Fungus is commonly supposed to be a species of this or a nearly allied genus. It would appear, however, that the so-called fungus, *Oidium*, is a mycelial form composed of conidial cells of some other fungus, probably a species of *Erysiphe*.

Penicillium glaucum, *Mucor mucedo*, *Aspergillus glaucus*, *Botrytis vulgaris*, *&c.*, in their fully developed conditions (*figs* 150—152), form the various kinds of Moulds already noticed. (See *Properties and Uses of Fungi.*) *Botrytis infestans* is the fungus seen in the Potato disease. The so-called Vinegar plant, which, by its growth in saccharine liquids at moderate temperatures, converts them into vinegar, appears to be a mycelial state of *Penicillium glaucum*; and the Yeast plant (*fig.* 142), which by its vegetation at a high temperature, causes fermentation in bread, beer, &c., would seem likewise to be a mycelial state composed of conidial cells of a species of *Penicillium*.

Natural Order 295. ALGÆ.—The Sea-weed Order.—Parenchymatous cellular plants; growing in salt or fresh water, or in moist situations. The thallus is foliaceous and branched (*fig.* 153), or filamentous (*figs.* 828 and 836), or pulverulent. Many Algæ are microscopic, and others are of large size. In colour they are usually greenish, rose-coloured, or brown. They are reproduced in various ways. (See pp. 388—393.)

Division of the Order, &c.—The order is commonly divided into three sub-orders, which are frequently regarded as distinct natural orders; these are known under the names of the *Melanosporeæ* or *Fucoideæ;* the *Rhodosporeæ* or *Florideæ;* and the *Chlorosporeæ* or *Confervoideæ.* To these sub-orders may be added two others, called respectively, *Diatomaceæ*, and *Volvocineæ.* The distinctive characters of these different sub-orders may be briefly described as follows :—

Sub-order 1. *Melanosporeæ*, *Fucoideæ*, or *Brown-coloured Algæ.* — Multicellular Algæ, growing in salt water, forming a foliaceous (*fig.* 153), or filamentous thallus (*fig.* 836), and of an olive-green or olive-brown colour. Reproduced by 1. *Zoospores* (*fig.* 836); 2. *Spores* (*figs.* 153, *t*, and 837); and 3. *Antheridia* (*figs.* 838 and 839.) (See pp. 391—393.) *Examples:* — Sargassum, Halidrys, Fucus, Chorda, Laminaria, Ectocarpus.

Sub-order 2. *Rhodosporeæ*, *Florideæ*, or *Rose-coloured Algæ.*— Marine multicellular plants, with a foliaceous or branched

filamentous thallus, and of a reddish-purple, rose-coloured, or reddish-brown colour. Reproduced by, 1. *Tetraspores* (*figs.* 831—833); 2. *Spores* (*figs.* 834 and 835); and 3. *Antheridia.* (See pp. 390, 391.)

Examples: — Corallina, Plocaria, Chondrus, Callithamnion, Ceramium, Porphyra.

Sub-order 3. *Chlorosporeæ*, *Confervoideæ*, or *Green-coloured Algæ.*—Unicellular or multicellular Algæ, growing in fresh or salt water, or in moist situations; usually of a bright green colour, or rarely red. Reproduced by, 1. *Spores*, formed either by *conjugation* (*figs.* 828 and 829), or by impregnation from *spermatozoids*; and, 2. *Zoospores* (*figs.* 14, 15, 146, 829 and 830). (See pp. 388—390.)

Sub-order 4. *Diatomaceæ.*—Brittleworts.—The following diagnosis is from Henfrey:—"Microscopic unicellular plants, occurring isolated or in groups of definite form, usually surrounded by a gelatinous investment, the cells exhibiting more or less regular geometrical outlines and enclosed by a membrane, striated (*fig.* 1095) or granular, either simply tough and continuous (*fig.* 1096), or impregnated with silex and separable into valves (*fig.* 1095). Reproduction by spores formed after conjugation of the cells (*fig.* 1096), by zoospores formed from the cell contents, and by division." The Diatomaceæ are again divided into two sections: 1. *Diatomeæ* (*fig.* 1095). Natives of fresh or salt water, of a

Fig. 1095.

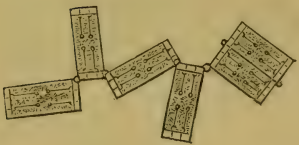


Fig. 1095. A species of Diatomaceous Alga (*Diatoma marinum*), dividing into parts by *merismatic* or *fissiparous* cell-division. The parts are seen to be striated.

Fig. 1096.

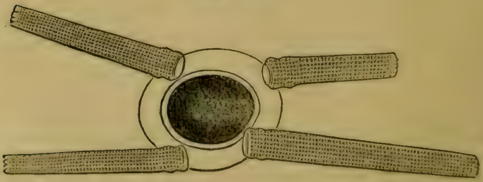


Fig. 1096. Two Desmidiaceous Algæ (*Docidium Ehrenbergii*) after conjugation, with a *resting* or *inactive* spore between them. After Ralfs.

brownish colour, valvular, and invested by a siliceous membrane. *Examples :* — Diatoma, Navicula. 2. *Desmidieæ* (*fig.* 1096). Found only in fresh water, of a green colour, continuous, and not invested by a siliceous membrane. *Examples :* — Closterium, Desmidium.

Sub-order 5. *Volvocineæ* (*fig.* 1097). Henfrey diagnoses them as follows : — "Microscopic bodies swimming in fresh water by the aid of cilia arranged in pairs upon the surface of a common semi-gelatinous envelope, the pairs of cilia each belonging to a green corpuscle resembling the zoospore of a confervoid, imbedded in the periphery of the common envelope. Reproduction by the development of each corpuscle into a new colony, the whole being set free by the solution of the parent envelope or by conversion of the corpuscles into encysted resting-spores like those of Confervæ." *Examples :* — Volvox, Gonium. The members of this group are frequently regarded as Infusorial Animalcules, but in all their essential characters they closely resemble the Confervoideæ.

Fig. 1097.

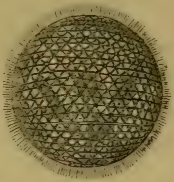


Fig. 1097. The Revolving Volvox (*Volvox globator*). The outer surface is ciliated.

Distribution, &c.—Algæ are more or less distributed throughout the globe, growing in salt or fresh water, or in moist situations. Some species are found in the boiling springs of Iceland, &c. ; others occur in mineral springs, and some in chemical solutions. The waters of whatever temperature have their own peculiar forms. It is impossible to estimate with any degree of accuracy the number of species of Algæ, but they may be roughly guessed at 2500.

Properties and Uses.—Several species are employed for food in different parts of the world; as, *Laminaria saccharina, digitata, potatorum, &c.; Alaria esculenta, Durvillæa utilis, Sargassum species, Iridæa edulis, Chondrus crispus* and *mamillosus, Gelidium corneum, &c., Gigartina speciosa, Laurencia papillosa, &c., Gracilaria lichenoides* and other *Gracilarias, Rhodymenia palmata, Porphyra vulgaris* and *laciniata, Ulva latissima, compressa, &c.; Nostoc edule, arcticum;* and many others. The nutritious properties of the above are due to the presence of starch, sugary matter (*mannite*), mucilage, and albumen. M. Payen has recently discovered a new principle in *Gelidium corneum* (*Algue de Java*), and some other Algæ, to which he has given the name of *Gelose.* To this substance also the nutritious properties of Algæ are, to a great extent, due. According to Payen, 1 part of *gelose* dissolved in 500 parts of boiling water, will

afford, upon cooling, a colourless, transparent jelly,—thus forming ten times more jelly than a like weight of the best animal gelatine. In order, therefore, to produce a jelly of equal consistence, it would be only necessary to employ the tenth part of what is necessary when isinglass is used. Jellies prepared from species of *Gelidium*, *Laurencia*, *&c.*, are much employed for food in China, Japan, &c. The edible birds' nests of China, so highly valued for food, seem to be constructed by swallows from these, or closely allied species of Algæ.

In medicine the above-mentioned nutritious Algæ may be used for their emollient and demulcent properties. Several species of Algæ, particularly *Fucus vesiculosus*, have been used as remedies in Goitre and scrofulous diseases. They owe their beneficial effects in such cases, principally, to the presence of a small quantity of iodine. The ashes obtained by burning many species of Algæ in the open air, form the substance called *kelp*, which was formerly much used for the preparation of carbonate of soda; but this is now more cheaply obtained from sea-salt. Iodine is, however, still obtained from kelp. Some Algæ have been reputed to possess vermifugal properties; none are known to be poisonous.

Several Algæ are remarkable for imparting colours to water, snow, &c. Thus, *Protococcus* (*Palmella*) *atlanticus* gives a red colour to certain parts of the Atlantic; *P. nivalis* contributes to communicate a red colour to snow; and *P. viridis*, a green tint; *Dolichospernum Thompsoni* imparts a green colour to the Serpentine and to some Irish and Scotch lakes; the red colour of the Red Sea is also in part attributed to the presence of *Trichodesmium erythræum*; &c. &c.

Some Algæ are met with in diseased animal tissues. The *Achlya prolifera*, which attacks the gills of gold fishes, &c., and *Sarcinula ventriculi*, found in the stomach, &c. of animals, may be enumerated as amongst the most remarkable of such forms.

Laminaria.—*L. saccharina* is remarkable for the large quantity of mannite it contains, upwards of 12 per cent. The young parts of it, mixed with those of *L. digitata*, are eaten in Scotland, &c., under the name of *Tangle*. The latter also contains much mannite. *L. saccharina* is called *Sea-tape* in China, where it is used for food and other purposes. *L. potatorum* is used for food in Australia, and other species possess similar properties.

Alaria esculenta (Bladderlocks, Hen-Ware, or Honey-Ware) contains mannite. It is employed for food in Ireland, Scotland, Iceland, and other northern regions of the world.

Fucus.—Several species contain mannite, as *F. vesiculosus*, *nodosus*, and *serratus*. *F. vesiculosus*, Sea Wrack.—This Alga is much used in winter in certain islands of Scotland for feeding horses and cattle. The expressed juice of its vesicles has been given internally, and frictions of the plant have been employed externally, in glandular and scrofulous affections. The substance called Vegetable Ethiops, which has been used in similar diseases to the above, is a kind of charcoal produced by the incineration of this Alga in close vessels. The beneficial effects in such cases is principally due to the presence of a small quantity of iodine. It was formerly extensively employed in the preparation of kelp.

Durvillæa utilis is used for food by the poorer inhabitants on the western coast of South America.

Halidrys siliquosa contains nearly 6 per cent. of mannite.

Sargassum.—S. bacciferum is the Gulf-Weed of the Atlantic. This and other species contain iodine, to the presence of which they owe their beneficial effects in Goitre, for which purpose stems of the *S. bacciferum* are much employed in South America under the name of *Goitre-sticks.*

Iridæa edulis, as its name implies, is nutritious, and is sometimes used for food in Scotland, &c.

Chondrus (*Sphærococcus*).—*C. crispus* is commonly termed Carrageen or Irish Moss. It possesses nutritive, emollient, and demulcent properties, and may be used in the form of a decoction, jelly, &c., in pulmonary complaints, &c. *Bandoline* or *fixature*, used for stiffening the hair, &c., is generally prepared from Carrageen. *C. mamillosus* is always found in the Carrageen Moss of the shops. Its properties are similar. Carrageen Moss is sometimes employed as a substitute for size.

Gelidium corneum, as already noticed, is nutritive. It is the *Algue de Java*, from which M. Payen first obtained *Gelose.* It forms a favourite article of food in Japan, &c., and is also used in the manufacture of a kind of glue, &c.

Gigartina speciosa is another edible Alga, in common use for food in certain parts of Australia, &c.

Laurencia.—L. pinnatifida is remarkable for possessing pungent properties. It is called Pepper-dulse in Scotland, where it is occasionally eaten. *L. papillosa* (Tan-shwui), is extensively employed in China and Japan in the preparation of a gelatinous substance called *Yang-Tsai.*

Gracilaria (*Plocaria*).—*G. lichenoides* or *Plocaria candida*, is our commercial Ceylon Moss. It is nutritive, emollient, and demulcent, and may be employed in the form of a decoction or jelly, as a food for children and invalids, and medicinally, in pulmonary complaints, diarrhœa, &c. It is sometimes imported under the name of *Agar-agar*, but *G. spinosa* (*Fucus spinosus* or *Eucheuma spinosa*), has been also imported under the same name. Both species are largely employed in the East for making nutritious jellies, for stiffening purposes, and for varnishing. *G. tenax* may be similarly used. *Gracilaria* or *Plocaria Helminthocorton* is Corsican Moss. It has been used principally as a vermifuge, but its properties have been much overrated. *G. crassa* (Ki-tsai), is cooked with soy or vinegar in China. It is also employed by the Chinese ladies to give a glossiness to their hair.

Rhodomenia palmata is an article of food in Scotland, Ireland, Iceland, &c. It is the *Dulse* of the Scotch, and the *Dillesk* of the Irish.

Porphyra laciniata and *vulgaris* are employed in the preparation of a kind of sauce or pickle, which is termed *Sloke*, *Slokan*, or *Laver*. *P. vulgaris* is eaten in China as a relish to rice. It is termed *Tsz-Tsai* (purple vegetable).

Ulva latissima is employed in the preparation of *Green Laver*. It is very inferior to the laver prepared from the species of *Porphyra*. Both these lavers might be beneficial in scrofulous affections, &c., as they contain iodine.

Nostoc.—N. edule is eaten in China, &c. *N. arcticum* is a valuable article of food in the Arctic regions; it is said by some to be far superior in this respect to Iceland Moss. Other species possess similar properties.

Artificial Analysis of the Natural Orders in the Sub-class THALLOGENÆ.

(The numbers refer to the Orders.)

1. Plants with a mycelium, growing in or on decaying or living organic matter, and fructifying in the air . . . *Fungi.* 294.
2. Plants without a mycelium.
   Living and fructifying in the air . . . . . . *Lichenes.* 293.
   Living in water, or in very moist situations . . . *Algæ.* 295.

BOOK III.

PHYSIOLOGY OR ORGANOLOGY.

Having now described plants in reference to their structure, classification, properties, and uses, we have, in the last place, briefly to consider them in a state of life or action, — that is, to explain, as far as science enables us, the laws which regulate their life, growth, and reproduction. The department of botany which investigates these phenomena is termed Physiology or Organology ; and the various processes which the plant performs, and which are the necessary accompaniments of its life, are called its *functions*. The different functions thus concerned in the life of the plant, are naturally divided into two classes, called, respectively, the functions of the organs of vegetation, and the functions of the organs of reproduction ; the former being those concerned in preserving the life of any particular plant, and the latter in continuing the species. Physiology includes the study of the life of the whole plant, when it is termed *general;* and that of the particular organs, in which case it is called *special.*

In the present unsatisfactory state of our knowledge of many points connected with the physiology of plants, we have much difficulty in arranging a good plan for its study. In treating, therefore, of the functions of the different organs, I shall follow, as far as possible, the order of arrangement adopted in treating of their structure and morphology, and conclude with a few observations on some special phenomena in the life of the plant.

CHAPTER 1.

SPECIAL PHYSIOLOGY.

Section 1.— Physiology of the Elementary Structures of Plants.

1. Functions of Parenchymatous Cells and Parenchyma. — As the simplest forms of Vegetable life, such as the Red Snow Plant (*Protococcus nivalis* or *Palmella cruenta*) (*figs.* 147 and 148) merely consist of a single cell, that cell is necessarily capable in such a case, of performing all the actions appertaining to plant life. Parenchymatous tissue also constitutes the whole structure of Thallogens, as well as the soft portions of all plants above them; hence the physiology of parenchymatous cells is of the first importance. The more important special functions observed in cells are, 1. The formation of new cells; 2. Absorption and transmission of fluids; 3. Movements in their contents; and, 4. Elaboration of their fluids, and production of the different materials necessary for development and secretion.

1. *The Formation of New Cells.*—All plants, as we have seen (p. 4), in their earliest conditions, are composed of one or more cells, hence, all the organs which afterwards make their appearance must be produced by the modification of such cells, or by the formation of new ones. The formation and growth of cells has already been treated of (see pp. 56—62), and need not be further alluded to. New cells may be either produced by division of the parent cells (p. 58); or by free-cell formation (p. 56), in the cavities of their parents.

2. *Absorption and Transmission of Fluids.*—The cell-wall of all young and vitally active parenchymatous or prosenchymatous cells is readily permeable by fluids, and we find, accordingly, that liquid matters are constantly being absorbed and transmitted through such cells. The power which thus enables cells to absorb and transmit fluids, is called *endosmose.* This physical force, as will be afterwards shown, is a most important agent in plant-life, for by its agency plants are enabled, not only to absorb crude food by their roots in a fluid state, but also to transfer it upwards, from cell to cell, to the leaves and other external organs, for the purpose of being elaborated by the action of light and air. It is, moreover, by a somewhat

analogous process (*diffusion of gases*), that the cells on the surface of plants are enabled to absorb and transmit gaseous matters.

Endosmose may be explained as follows : — Whenever two fluids of different densities are separated by a permeable membrane which is capable of transmitting them, there will always be a tendency to equilibrium of density between the two, from the formation of a double current,—one passing from the thinner to the denser liquid, and the other, from the denser to the thinner. This endosmotic action may be easily observed, by filling a bladder with a coloured syrup, attaching to its open end a glass tube, and then immersing it in a vessel containing water (*fig.* 1098). Under such circumstances, the volume of the denser fluid in the interior of the bladder becomes increased (as may be at once seen by its rise in the tube), by the passage through the membrane of the thinner fluid; whilst, at the same time, a portion of the thicker liquid passes out into the water or thinner fluid, as may be proved by the sweet taste and colour which it gradually acquires. This double current will continue as long as there is any material difference of density in the two liquids. The stronger in-going current is termed *endosmose*, and the weaker out-going current, *exosmose*. If the position of the liquids be reversed, the currents will be reversed in like manner, the preponderating current, in almost all cases, being that which sets from the thinner to the denser liquid. This rapidity, however, is modified to some extent by the nature of the membrane ; for if two different liquids are separated by a membrane, that will pass through most readily which is most freely imbibed by the membrane.

Fig. 1098.

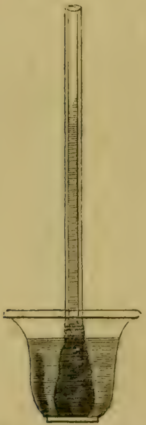


Fig. 1098. Apparatus to show *endosmose* and *exosmose*. It consists of a bladder filled with syrup, to the open end of which a tube is attached, and the whole placed in a vessel containing water.

The absorption and transmission of liquid matters through cells is now very easy to explain, for as the fluid contents of the cells of the roots of plants are denser than the water contained in the media in which they grow, they will continually absorb by endosmose (see *Absorption*); and as the changes which are going on in the cells by assimilation and other processes on the surface of plants tend to thicken their contained liquids, there will also be a constant passage of the absorbed fluids from cell to cell towards those parts where such processes are taking place.

3. *Movements in the Contents of Cells.* — In many cells, and probably in all at a particular period of their life, when they are in a vitally active state, a kind of movement or rotation of a portion of their contents takes place. This movement is sometimes erroneously considered as a kind of circulation or rotation of the watery cell-sap, but the very complete observations of Mohl have proved, that it is due to a circulation of the protoplasm, which is rendered visible by the opaque granular particles which it contains (*figs.* 1099 and 1100). The protoplasm thus circulating, does not pass from one cell to another, but is strictly confined to the respective cells in which it originates. This kind of movement has been termed *Rotation*, *Gyration*, or *Intra-cellular Circulation.* This movement ceases, in the generality of cases, in cells when they have attained a certain size, but in those of many aquatic plants it continues throughout their life.

The appearances presented by these movements vary in different cases. Thus, in the cells of many hairs, as in those of

Fig. 1099.

Fig. 1100.

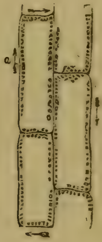


Fig. 1099. Three cells of one of the hairs of the common Potato plant, showing the circulation of the contents of each cell in reticulated currents. In the central cell the direction of the currents is in part indicated by arrows. After Schleiden.

Fig. 1100. Cells of the leaf of *Vallisneria spiralis*, showing the circulating current with its granular contents, passing up one side of each cell, across, and down on the other side. The direction of the currents is indicated by the arrows.

the Common Spider-wort (*Tradescantia virginica*), and Potato (*Solanum tuberosum*) (*fig.* 1099), the circulation is in reticulated currents, radiating apparently from, and returning to, the nucleus. In the cells of the leaves of *Vallisneria* (*fig.* 385), and in those of other parts of the same plant, intra-cellular movements

may be readily observed when they are submitted to a moderate microscopic power; but here, the protoplasm with its granular contents, will be seen to pass round the interior of the walls of each cell (*fig.* 1100). In the *Characeæ* again, and especially in the *Nitellæ* the more transparent forms of such plants, the moving protoplasm does not rotate round the walls, or in reticular currents, but it passes obliquely up one side of the cell (*fig.* 1094) until it reaches the extremity, and then flows down in an opposite direction on the other side.

No satisfactory explanation has as yet been brought forward to account for this movement of the cell-contents, all that we know is, that it is connected with the vitality of the plant, and hence all agents that actually injure the cell will stop it at once and permanently. The movements of the *ciliated zoospores* of the Algæ (see p. 389 and *figs.* 829 and 830), and those of the *ciliated spermatozoids* of the Algæ (see p. 393 and *fig.* 838) and of the higher Cryptogamic plants (see p. 370 and *fig.* 785), are regarded by Henfrey and others, as "*analogous to the rotation of the protoplasm.*"

4. *Elaboration of the Cell-contents.*—All cells exposed to light and air which contain a primordial utricle, have the power of producing in their contents, the various azotized and unazotized compounds which are concerned in the development of new tissues, and in the formation of the various secretions of the plant. (See *Respiration* and *Assimilation.*) In old cells the secretions of the plant are also, in part, deposited.

2. Functions of Prosenchyma.—Prosenchymatous cells are especially adapted by their construction and mode of combination into a tissue, for giving strength and support to plants; hence there can be no doubt, but that this is one of the offices which they perform. In a young state, also, before such cells are filled with secondary deposits, they appear to be the main agents, by which the fluids absorbed by the roots, are carried upwards to the leaves and other external organs, to be elaborated by the agency of light and air. The experiments of Hoffman, Unger, and others, would seem clearly to prove this. Thus, Hoffman, by placing plants in such a situation as to cause them to absorb a solution of ferrocyanide of potassium, and then adding a persalt of iron to sections of them, found that the prussian blue which was formed by the reaction of the chemical agents thus applied, was principally deposited in the prosenchymatous cells. Unger also, came to the same conclusion, by causing plants to absorb a coloured juice, and tracing its passage. It should be noticed, however, that other experimenters, such as Link and Rominger, have arrived at diametrically opposite conclusions. (See *Vessels*, below.)

3. Functions of Vessels.—The functions of the spiral, annular, reticulated, pitted, and scalariform vessels have been a subject

of much dispute from an early period, and have been repeatedly investigated. Hales, Bischoff, and others, came to the conclusion that, these vessels were carriers of air; while Dutrochet, Link, Rominger, &c., believed that their essential function was to carry fluids from the root upwards. According to Link, when plants are watered for several days with a solution of ferrocyanide of potassium, and afterwards with a solution of persulphate of iron, prussian blue is found in the vessels, and not in the prosenchymatous cells, as the experiments of Hoffman alluded to in speaking of the functions of prosenchymatous cells would seem to prove (see page 726). The opinion now more generally entertained is, that the vessels in their normal condition in the regular course of vegetation contain air, but that when plants are gorged with fluids, as in the spring of the year, they, as well as the prosenchymatous cells (the usual carriers of fluids), are filled with sap, and assist in its diffusion throughout the plant.

Functions of Laticiferous Vessels or Canals. — The physiological importance of these vessels has given rise to much discussion, and is at the present time involved in obscurity. Nothing further is absolutely known, than that they contain a watery granular fluid which becomes milky on exposure to air, and to which the name of latex has been given. (See p. 37.) Lindley, and some other authors, believe, that they "convey the elaborated sap of a plant to the places where it is needed, and especially down the inner part of the bark of Exogens." Schultz called the tissue formed by the ramifications of the laticiferous vessels, *cinenchyma*, because he believed that he had discovered in it a peculiar vital movement or circulation of the latex, to which he gave the name of *cyclosis*. This movement may be generally observed, by placing a leaf of the common Celandine (*Chelidonium majus*), previously dipped in oil, under the microscope, and is described by Balfour "to resemble in many respects the appearance presented by the circulation in the web of a frog's foot." We have, however, never succeeded in observing such an evident circulation in any laticiferous tissues examined by us, although we agree with Schultz, Balfour, Carpenter, and others, that a kind of vital movement of the latex does occur in the uninjured plant. Amici, Treviranus, Mohl, Henfrey, and others, altogether deny the existence of any such a movement in uninjured tissues, and describe the circulation as depending "upon a disturbance of the equilibrium by external causes, such as pressure and heat, and may be produced at will in any direction by making an incision, towards which the juice flows." Further investigation is, therefore, necessary, before we can come to any positive conclusions upon this subject.

Recently, Trécul has propounded a new theory as to the

functions of the laticiferous vessels. As already stated (p. 38), Trécul believes that he has seen the laticiferous vessels in many milky plants, communicating freely with the other vessels, and he concludes that they act as venous reservoirs to the circulating fluid. Trécul having kindly afforded us an opportunity of examining several of his microscopic preparations, which he believed would prove the connection of the true vessels with the laticiferous, we are bound to state, that we could not satisfactorily trace any such a union as he has described.

4. Functions of Epidermal Tissue and its Appendages. — The special functions of these parts are: — to protect the tissues beneath from injury, and from being too rapidly affected by atmospheric changes; to regulate the transpiration or exhalation of watery fluids; to absorb and exhale gaseous matters; and probably, to some extent, to absorb water. The epidermis itself, is specially designed to prevent a too ready evaporation of fluid matters from the tissues beneath, and hence, we find, that it is variously modified to suit the different conditions to which plants are submitted. Thus, in submersed plants, which are always exposed to similar influences as regards moisture, there is no true epidermis; whilst in aerial plants submitted to ordinary influences in cold and temperate climates, we generally find an epidermis with only one layer of thin-sided cells, and covered by a cuticle of only moderate thickness. In other aerial plants, however, growing in the same latitudes, such as the Box, &c., and generally in those of a succulent nature where there is but a moderate exhalation, we find the upper walls of the epidermal cells especially thickened, or protected by a dense layer of cuticle; whilst in aerial plants growing in very dry regions, and more especially in those of warm and tropical climates, as the Oleander (*fig.* 81), we have frequently an epidermis of two, three, or more layers of thick-sided cells, and other special contrivances to prevent a too ready exhalation of fluids. While the epidermis may thus be shown to have for its object the restraining of a too abundant exhalation, the *stomata* are especially designed to facilitate and regulate the passage of fluid matters, and in proportion to their number, therefore, upon the different organs and parts of plants, *cæteris paribus*, so will be the exhalation from them. The exact manner in which the stomata act is not readily explained, but it may be always noticed, that when plants are freely supplied with moisture, that the stomata have their bordering cells distended with fluid, and curved outwards, so that the orifices between them are open; whilst in those cases, where there is a deficiency of fluid, the bordering cells contract, straighten on their inner surfaces, and thus close the orifices. Under the former condition of stomata, there is a ready communication with the external air and the internal tissues, and hence a free exhalation takes place;

while in the latter state, the exhalation is more or less prevented. In all the above cases of adaptation of the epidermis and stomata to the conditions under which plants are placed, it is impossible not to be struck with the wonderful evidences of Design exhibited.

It is also through the cells of the epidermis, and more especially through the stomata, that certain gaseous matters are absorbed from, and exhaled into, the atmosphere, in the processes of Respiration and Assimilation. (See these processes.)

Hairs and their modifications, appear to be designed, to protect the epidermis and parts beneath from injury from cold and other external influences, hence, we find young buds, &c., frequently coated with hairs. Hairs also appear in certain instances, at least to some extent, to absorb fluid matters from the atmosphere, &c.; whilst in other cases, they serve to assist the epidermis in restraining exhalation, and we find accordingly, that plants which are densely coated with them, are well adapted to grow in dry arid situations, and to withstand without injury a season of drought.

Glands are those organs which contain some of the peculiar secretions of the plant. These secretions are either permanently stored up in them, or excreted.

It is still a disputed question whether the epidermal tissue and its appendages have the power of absorbing liquids, such as water. Some authors, as Unger, not only deny the possession of such a power, but also that of taking up watery vapour. We think, however, that there can be no doubt upon the latter point, for otherwise, how is it possible to account for the immediate recovery of drooping plants in a greenhouse, when water is sprinkled upon the floors, &c., or the revival upon a large extent in nature, of vegetation, when a mist follows a long succession of dry weather,—except by believing that watery vapour is taken up by the epidermal tissue and its appendages? Whether water itself is absorbed by the epidermal tissue and its appendages is very doubtful. Various experimenters have endeavoured to show that they have this power. The researches of Garreau led him to the following conclusions:—1. That the cuticle possessed an evident endosmotic property, the intensity of which was in proportion to the age of the tissues which it invested; thus it was greatest when they were young, and gradually diminished as they approached maturity, and was altogether lost when they became old. 2. The absorption of the cuticle was greater in proportion to the absence of waxy or fatty matters. 3. The cuticle covering the upper surface of the ribs, and especially of that of the petiole where it joins the stem, is that part of the leaf surface which presents the most marked power of absorption. 4. In certain instances in which the cuticle is absorbent, the epidermis presents impediments to ab-

sorption. 5. Simple washing with distilled water, and more especially with soap and water, augments the absorptive power. 6. When the epidermal tissues of leaves have lost their power of absorbing water, they can still absorb carbonic acid.

5. FUNCTIONS OF THE INTERCELLULAR SYSTEM.—The *intercellular canals*, except in those cases in which the tissues of the plant are gorged with sap, as in the spring of the year, are filled with air, and the especial function which they perform is, to allow a communication between the external air and the contents of the internal tissues by virtue of the laws regulating the diffusion of gases. They also facilitate exhalation of liquid matters by their connection with the stomata. The *intercellular spaces* are also, in most cases, filled with air; while the *air-cells* and *cavities*, as their names imply, are in like manner filled with aeriform matters, and in water plants, are especially designed to diminish the specific gravity of the parts in which they are found, and thus to enable them to float readily. The *receptacles or reservoirs of secretion*, as their name implies, contain the peculiar secretions of certain plants, and are hence closely allied in their nature to glands.

Section 2.—PHYSIOLOGY OF THE ORGANS OF NUTRITION OR VEGETATION.

1. OF THE ROOT OR DESCENDING AXIS.—The offices performed by the root are: — 1. To fix the plant firmly in the earth or to the substance upon which it grows, or in some cases, as in many aquatic plants, to float it in the water; 2. To absorb liquid food; 3. According to some authors, to excrete into the soil certain matters which are injurious, or at least not necessary for the healthy development of the plant; 4. To act as a reservoir of nutriment.

The office which the root performs of fixing plants in those situations where food can be obtained, is evident, and needs no further remarks. It is also essential to the proper performance of its absorptive powers.

Absorption by the Root —The function which the root performs of absorbing nutriment for the uses of the plant, from the materials in or upon which it grows, is not possessed by its whole surface, but is almost exclusively confined to the cells and fibrils (*fig.* 232) of the newly developed portions and young parts adjacent to them. Hence, in the process of transplanting, it is necessary to preserve such parts as far as possible, otherwise the plants thus operated upon will languish or die, according to the amount of injury they have sustained. The injury done to plants in transplanting, is also to a great extent influenced by atmospheric circumstances and conditions of the soil at the time in which such an operation is performed; thus, under the favour-

able circumstances of a warm soil and moist atmosphere the destruction of a large portion of the young extremities of the root will do but little injury, as the plant will then speedily form new absorbent extremities, but if the conditions of the earth and soil be the reverse of those stated above, then a large destruction of the young extremities of the roots will cause the plant to die before new absorbent extremities can be formed. Special attention should be paid to the above facts when transplanting is performed in the growing season; but it is far better, when possible, to transplant late in the summer or in the autumn when the growing season is drawing to a close, or in the spring before it has recommenced, as at such periods, little or no absorption takes place, and the plants have accordingly time to recover themselves, before they are required to perform any active functions. (See pages 779 and 780.)

This absorption of food by the young extremities of the roots is due to endosmose taking place between the contents of their cells and the fluids of the surrounding soil, and the immediate cause of this action is the greater density of the cell-contents of the roots produced by the vital actions which are there going on. (See page 781.)

Roots, as we have already seen (page 119), only grow in length by additions near to their extremities, and as it is at these parts that absorption of food almost entirely takes place, they are always placed in the most favourable circumstances for obtaining it, because in their growth they are constantly entering new soil, and hence, as one portion of that soil has its nutritious matters extracted, another is entered which is in an unexhausted state.

Roots can only absorb substances in a liquid state, and hence the different inorganic substances, &c. which are derived from the soil, and which form an essential part of the food of plants (page 777), must previously be dissolved in water. If the roots of a freely growing plant be placed in water in which charcoal in the most minute state of division, has been put, as that substance is insoluble in the fluid, it will remain on the surface of the roots, and the water alone will pass into them; thus showing that substances in solution are alone taken up by roots.

Various experiments have been devised to ascertain whether the plant possesses any power of selecting food by its roots. Saussure proved, that when the roots of plants were put into mixed solutions of various salts, some were taken up more freely than others. He also found, that dead or diseased roots absorbed differently to those in a vital condition. The experiments of Daubeny, Trinchinetti, and others, lead essentially to the same conclusions. Again, if the seeds of two different plants, such as the common bean and wheat, be sown in the same soil, and exposed, as far as possible, to the same influences in their after

growth and development, it may be shown by chemical analysis afterwards, that the wheat stalk will contain a much larger proportion of silica, (which it must have obtained from the soil,) than that of the bean.

The experiments of Bouchardat, Vogel, and others, appear, on the contrary, to indicate that roots absorb all substances presented to them indifferently, and in equal proportions. The simple fact, however, which is easily proved by chemical analysis—that the ashes of different plants contain different substances or in different proportions, seems to me to prove incontestably, that roots have a power of selecting their food. In using the term *selecting*, however, we do not intend to imply that roots have any inherent vital power of selection resembling animal volition, but only to express the result produced by virtue of the mutual actions of the root and the substances which surround it in the soil. This power or property of selection is without doubt due to some obscure, and at present but little understood molecular relation which exists between the membranes of the cells of different plants and the substances which are taken up or rejected by them, by which different roots acquire different endosmotic action for the same substances, while those of the same plant, in like manner, possess a varying endosmotic action for different substances. It follows also, from the recognition of endosmotic action as the cause of the absorption of fluid matters by the plant, that poisonous substances may be also taken up when in solution by the roots, provided their tissues are not injured by them in their passage; and we find accordingly, that when injurious substances are found in the soil a corresponding effect is produced upon plants by their absorption.

Excretion of Roots.—The roots of plants have been considered by Brugmans, Plenk, De Candolle, Macaire-Prinsep, and others, to possess the power of excreting into the soil certain of their peculiar secretions. Thus Prinsep found, that the Lettuces and Poppies excreted a matter analogous to opium; the *Leguminosæ* gummy matters; the *Euphorbiaceæ* acrid matters, &c.; and it was therefore concluded by De Candolle and others, that such substances were thrown off by plants because they were injurious to them. It was also believed that while such substances were injurious to the plants producing them, they were beneficial to others; and as plants could not therefore be grown for any length of time in soil impregnated with their own injurious excretions, rotation of crops was necessary. (See p. 777).

These experiments, when repeated by Braconnot, Walser, Meyen, Boussingault, &c., with every precaution, did not lead to the same results, but, on the contrary, to the conclusion—that the effects observed by Macaire-Prinsep were due to his experiments having been made without sufficient care, and that no excretions of the peculiar substances of the plant took

place unless the roots of such plants were injured. While it may be proved, therefore, that excretions from the roots can have no influence on the rotation of crops, still it is by no means proved that roots do not impart some of their contents to the soil. The evidence, so far as we are able to judge, would seem to lead to the conclusion, that roots have no power of getting rid of excrementitious matters like that possessed by animals, but nevertheless that they do throw off into the soil a portion of their contents by a process of exosmose, which appears to be a necessary result and accompaniment of endosmose by which absorption takes place.

Roots are frequently enlarged for the purpose of acting as reservoirs of nutriment in the form of starchy, gummy, and similar matters, for the future support of the plant. The tubercles of the dahlia (*fig.* 244) and orchis (*figs.* 242 and 243), and the roots of the turnip (*fig.* 250) and carrot (*fig.* 248), are familiar illustrations of such roots.

2. Of the Stem or Ascending Axis. — The offices performed by the stem and its ramifications are: — 1. To form a support for the leaves and other appendages of the axis which have but a temporary existence, and thus enable them to be freely exposed to the influences of light and atmospheric air, which are essential for the proper performance of their functions and development; 2. To convey air and fluid matters upwards, downwards, and inwards, to the organs of respiration, assimilation, development, and secretion; and 3. To act as a reservoir for the secretions of the plant.

Special Functions of the different Parts of the Stem. — 1. *The Pith.*—Various functions have at different times been ascribed to the pith. In the young plant, and in all newly formed parts, the cells of the pith are filled with a greenish fluid containing gum and other nutritious substances in a state of solution. As the parts increase in age the pith loses its colour, becomes dry, and is generally more or less destroyed. Hence it appears to serve the temporary purpose of nourishing the parts which surround it when they are in a young state. The pith also, in some cases, acts as a reservoir for the secretions of the plant.

2. *The Wood.* — The wood-cells, when in a young and pervious condition, are the main agents by which the crude sap is conveyed to the external organs to be aërated and elaborated; whilst the vessels of the medullary sheath and other parts are carriers of air through the plant, and only in exceptionable cases convey fluids. (See pages 726 and 727.) As the wood increases in age, the tissues of which it is composed become filled with various secretions by which they are hardened and solidified, and in this manner the stem acquires strength and firmness. On the outside of the young wood, but organically

connected with it and with the bark of Dicotyledons, is the vitally active layer of cells called the cambium layer, from which are annually formed new layers of wood and inner bark. The cells of the cambium layer are filled in the spring and at other seasons when growth takes place, with elaborated sap, or that sap which contains all the materials necessary for the development of new structures. Great differences of opinion exist amongst botanists as to the exact manner in which wood is deposited, but they are nearly all agreed that the materials from which it is formed are elaborated in the leaves, and that hence without leaves there can be no additions to the wood, and in proportion to their amount so will be the thickness of the wood. It is necessary, therefore, that the process of pruning timber trees should be carefully conducted. As the formation of the elaborated sap also depends upon the proper exposure of the crude sap to air and light, and as new wood is formed out of the materials it contains, it is necessary when trees are planted for timber that they should be placed at proper intervals, in order that they may be freely exposed to those influences which are favourable for their development.

3. *The Medullary Rays.*—The principal function which these rays perform is, to convey a portion of the elaborated sap from the bark and cambium layer through the wood, in which certain of the secretions it contains are ultimately deposited.

4. *The Bark.*—The bark acts as a protection to the young and tender parts within it; it also conveys the elaborated sap from the leaves downwards, in order that new tissues may be developed, and the different secretions deposited in the wood and in its own substance. The bark frequently contains very active medicinal substances, and others which are useful in the arts, &c.

3. Of the Leaves. — The essential functions of the leaves are:—1. The exhalation of the superfluous fluid of the crude sap in the form of watery vapour; 2. The absorption of fluid matters; 3. The absorption and exhalation of gases; and 4. The formation of the various organic products and secretions of plants. These functions they are enabled to perform through the influence of the air and light, to which agents, by their position on the ascending axis of the plant, they are necessarily, under ordinary circumstances, freely exposed.

1. *Exhalation of Watery Vapour by Leaves.* — This process, which is commonly termed *transpiration*, is considered to be somewhat analogous to the perspiration of animals. Its immediate object is, the thickening of the crude sap, and the consequent increase of solid contents in any particular portion of it. This transpiration of watery vapour, as already noticed (see p. 728), takes place almost entirely through the stomata, and hence as a general rule the quantity transpired will be in proportion to their number. The presence or absence of a true epidermis and the various

modifications to which it is liable, have also an important influence upon the transpiration of fluid matters. (See p. 728.)

From some interesting experiments of M. Garreau on the transpiration by leaves, he was led to draw the following conclusions :—1. That the quantity of water exhaled by the upper and under surfaces of the leaves is usually as 1 to 2, 1 to 3, or even 1 to 5, or more. The quantity has no relation to the position of the surfaces, for the leaves, when reversed, gave the same results as when in their natural position. 2. There is a correspondence between the quantity of water exhaled and the number of the stomata. 3. The transpiration of fluid takes place in greater quantity on the parts of the epidermis where there is least waxy or fatty matter, as along the line of the ribs.

This transpiration of fluids is influenced to some extent by the varying conditions of the atmosphere as to moisture and dryness ; thus, if two plants of the same nature are submitted to similar conditions, except that one is placed in a dry atmosphere, and the other in a moist, the former will give off more fluid than the latter. The great agent, however, which influences transpiration, is light. According to De Candolle, light is the only agent which is capable of promoting and modifying transpiration. He says, " If we take three plants in leaf, of the same species, of the same size, and of the same degree of vigour, and place them, after weighing them carefully, in close vessels,—one in total darkness, the other in the diffused light of day, and the third in the sunshine, and prevent absorption by the roots, we shall find that the plant exposed to the sun has lost a great quantity of water, that in common daylight a less amount, and that which was in total darkness almost nothing." The experiments of Henslow, Daubeny, and others, also demonstrate, in a most conclusive manner, the great influence of light upon transpiration. Daubeny, moreover, found that the different rays of the solar spectrum had a varying influence, the illuminating rays having more effect than the heating rays.

Light being thus shown to be the main agent concerned in influencing and modifying transpiration, this process will necessarily vary in amount, not only in the same latitudes with different degrees of light, but also in different latitudes according to the intensity of the light which is found in them respectively. Hence, under similar circumstances, the amount of transpiration from a given surface will be greater in tropical and warm-regions where solar light is most intense, than in temperate and cold ones; and thus we see one reason, why plants of those climates are frequently protected from an excessive and injurious exhalation by certain special adaptations of their epidermal tissues and appendages. (See p. 728.)

The quantity of fluid thus exhaled has been the subject of various experiments. The most complete observations upon

this point were made by Hales. He found that a common Sunflower $3\frac{1}{2}$ feet high, weighing 3 pounds, and with a surface estimated at 5616 square inches, exhaled on an average, about twenty ounces of fluid in the course of the day; a Cabbage-plant, with a surface of 2736 square inches, exhaled about nineteen ounces per day; a Vine, with a surface of 1820 square inches, from five to six ounces; and a Lemon-tree, exposing a surface of 2557 square inches, six ounces on an average in a day. If such a large amount of fluid be thus given off by single plants, what an enormous and almost incalculable quantity must be exhaled by the whole vegetation of the globe, and it is in this manner that a large supply of moisture is constantly thrown off into the atmosphere; and hence we can readily understand one cause which leads to the difference between the air of a thickly wooded country and that in which vegetation is more or less scanty, for the former will be always in a damp condition, while the latter will be comparatively free from humidity. Thus, we see that a country to be perfectly healthy, should have the proportion of plants to a particular area carefully considered, for while, on the one hand, too many plants are generally prejudicial to health by the dampness they produce; on the other, a deficiency or want of them, will produce an equally injurious dryness. The same circumstances have an important bearing upon the fertility or otherwise, of the soil, and thus have an indirect influence upon the health of the inhabitants. Thus, it is a fact, that as vapour is constantly given off by plants, rain is more abundant in those regions which are freely supplied with forests, than in those which are comparatively free from them, and we find accordingly, that a great change may be produced in the climate of a country by clearing it of forests, for while an excessive amount of vegetation is injurious to the healthy growth of plants, if the country be deprived of them, it will become entirely barren from its extreme dryness. By inattention to these simple but most important facts, which clearly indicate, that open land and that furnished with plants should be properly proportioned the one to the other, many regions of the globe which were formerly remarkable for their fertility, are now barren wastes; and in like manner, many districts formerly noted for their salubrity, have become almost, or quite, uninhabitable.

The fluid which thus passes off by the leaves of plants is almost pure water. This transpiration of watery vapour must not be confounded with the excretion of water containing various saline and organic matters dissolved in it, which takes place in certain plants, either from the general surface of the leaves or from special glands. In the peculiar formed leaves of Dischidia, Nepenthes (*fig.* 367), Sarracenia (*fig.* 368), and Heliamphora (*fig.* 369), watery excretions of this nature always exist. From the extremities or margins of the leaves of various

Marantaceæ, Musaceæ, Araceæ, Graminaceæ, &c., water is constantly excreted in drops at certain periods of vegetation. The most remarkable plant of this kind, however, is the *Caladium distillatorium*, from which half a pint of fluid has been noticed to drop away during a single night, from orifices placed at the extremities of the leaves, and communicating freely with internal passages.

2. *Absorption of Fluids by Leaves.* — This matter has already been considered when treating of the Functions of the Epidermal Tissue and its appendages (see page 729), and need not be further alluded to.

3. *Absorption and Exhalation of Gases by Leaves.*— We have already noticed (pp. 730 and 731) the property possessed by the roots of absorbing liquid food from the medium in which they grow, and also their supposed power of excretion (p. 732). Whilst plants are thus intimately connected by their roots with the soil or medium in which they are developed, they have also important relations to the atmosphere by their leaves and other external organs, which are constantly absorbing from, or exhaling into it, certain gases. The gases which are thus absorbed and exhaled by the leaves, have been proved by a vast number and variety of experiments, to be essentially carbonic acid and oxygen. Draper, Mulder, Cloez and Gratiolet, and others, also believe, that leaves and other parts, exhale nitrogen when exposed to sunlight. Again, the experiments of M. Ville would lead to the conclusion, that plants under certain circumstances, also absorb nitrogen from the air, but the recent able investigations of Lawes, Gilbert, Daubeny, and Pugh, so far as they extend, do not confirm his results, but tend, on the contrary, to negative them. The whole matter connected with the subject of the absorption and exhalation of other gases rather than those of carbonic acid and oxygen gases, is in an undetermined state, and our future remarks will almost entirely apply to the latter.

The absorption and exhalation of carbonic acid and oxygen gases by the leaves, vary according to the circumstances in which they are placed. Thus, when the green leaves of a healthy plant are exposed to sunlight, all experiments show, that carbonic acid gas is absorbed from the atmosphere, decomposed, leaving its carbon, which is the result of the decomposition, behind, and evolving its oxygen. It is in this way, that by far the largest proportion of carbon, which, as will be presently shown, is so essential to plants, is taken up by them.

This evolution of oxygen by the green leaves and other green organs may be readily observed taking place in the form of bubbles, when a submersed aquatic plant or some freshly gathered leaves placed in water, are exposed to the direct rays of the sun. These bubbles are oxygen gas. No such evolution of oxygen takes place unless the water contains carbonic acid gas, and not

therefore, in pure distilled water, or in that which has been recently boiled. It has been found also, that there is a constant relation between the amount of carbonic acid gas absorbed and the oxygen exhaled. These experiments prove therefore, not only the exhalation of oxygen by the leaves, but also that it must be derived by the decomposition of the absorbed carbonic acid. These changes do not take place in the deep-seated tissues of the plant, nor in the epidermal cells, but in those immediately beneath them.

This absorption of carbonic acid with fixation of carbon and evolution of oxygen, is in direct proportion to the intensity of the light to which the plants are exposed; but the experiments of Draper, Hunt, and others, show that the different rays of the spectrum have a varying influence in promoting such a decomposition. The results obtained by Draper by exposing the green parts of plants to the different rays of the spectrum were, that no oxygen was set free by them when they were in the violet and indigo rays; ·00 to ·33 only when in the extreme red ray; 1 in the blue; 4·10 in the green and blue; 43·75 in the yellow and green; and 24·75 in the red and orange. Hence he concluded, that the illuminating rays have the greatest effect in promoting decomposition of carbonic acid, those nearest them much less so, and the heating and chemical rays none at all. The experiments of Cloez and Gratiolet lead substantially to the same conclusions.

Whilst the absorption of carbonic acid and evolution of oxygen is thus taking place by day, it is supposed by most observers, that in the absence of light, a contrary change takes place,—oxygen being then absorbed, and carbonic acid exhaled. At the same time, all who hold this opinion admit, that the amount of oxygen gas thus absorbed by night, is very much less than that given off by day. Thus, the experiments of Saussure and Daubeny prove, that if plants be enclosed in jars containing ordinary atmospheric acid, and be supplied under such circumstances with carbonic acid, that the quantity of oxygen gas in the contained air becomes increased.

Some authors, such as Burnett, Carpenter, and Garreau, maintain that carbonic acid is given off by the leaves in varying quantities, both by day and night; whilst others again, such as Pepys, and Cloez and Gratiolet, deny that leaves, at any time when in a healthy state, give off carbonic acid.

Those who hold the more generally received opinion—that leaves when exposed to solar light give off oxygen gas, in consequence of the absorption and decomposition of carbonic acid, and that a contrary change takes place by night; take different views upon the nature of these changes. Most of them regard the evolution of oxygen by day as a true vegetable respiration, and hence they look upon vegetable respiration as affording

diametrically opposite results to that of animal respiration, upon the atmosphere we breathe. Others, such as Mohl and Henfrey, say that here we have two distinct functions going on,—*one*, taking place by day, and consisting in the consumption of carbonic acid, with fixation of carbon and evolution of oxygen; and *another*, only occurring by night, in the leaves and other green parts, but also by night and day, in those not green, and which consists in the absorption of oxygen and evolution of carbonic acid. The former function they regard as a process of *assimilation*, and the latter as a kind of *respiration*.

Those who maintain Burnett's views, also regard the constant exhalation of carbonic acid by day and night, as constituting vegetable respiration; and the exhalation of oxygen by day, as connected with assimilation.

The supporters of Pepys' views regard the exhalation of oxygen gas as a vegetable respiration. Pepys says that oxygen is given off by the leaves both by night and day, but in a greatly accelerated degree during the day; but by most observers no evolution of oxygen has been traced at night.

It will be seen from the above abstract of the views of different physiologists, that various opinions are entertained by them as to the action of the leaves and other green organs under different degrees of light; and also upon the character of such changes. Generally, it may be stated,—that all agree as to the evolution of oxygen by the green parts of plants under the influence of solar light, and that most authors call this vegetable respiration; that the evolution of carbonic acid by night is extremely small as compared with the opposite change by day, and is altogether denied by some authors; and that the constant exhalation of carbonic acid by day and night, in healthy leaves, is very doubtful.

Whatever views we may entertain, all admit that this evolution of oxygen gas by day has a most important influence in Nature. This will be at once evident when I state, that it is the only known process by which the oxygen gas, which is so essential to our existence, and which is constantly being removed from the atmosphere we breathe, by the respiration of man and other animals, by the process of combustion, by oxidation of mineral matter, and by other processes which are constantly going on upon the globe,—is restored to it in a free condition. Suppose that plants had not this power of restoring oxygen to the air by their respiration, it would necessarily happen that, the proportion of oxygen in it would gradually diminish, and in its place we should have a corresponding amount of the poisonous carbonic acid gas, and the effect would be ultimately, that the air we breathe would become unfit for animal life, precisely as the air of a close room where charcoal is burned would, from similar changes, destroy life. But such is not the case, for chemical

analysis shows, that the amount of oxygen present in the air under ordinary circumstances, is not liable to appreciable variation, and we find, accordingly,—that whilst man and other animals vitiate the atmosphere by robbing it of oxygen gas in their respiration, and by the various processes which are necessarily carried on by them, plants purify it by restoring that vitally necessary gas in their respiration. Thus we see that, "the two great organised kingdoms of nature are made to co-operate in the execution of the same design ; each ministering to the other, and preserving that due balance in the constitution of the atmosphere which adapts it to the welfare and activity of every order of beings, and which would soon be destroyed were the operations of either of them to be suspended. It is impossible to contemplate so special an adjustment of opposite effects without admiring this beautiful dispensation of Providence, extending over so vast a scale of being, and demonstrating the unity of plan upon which the whole system of organised creation has been devised."

In a like manner, plants purify the water in which they grow, and render it habitable by animals. We all know by early experience, that if any kind of fish be placed in water in which no plants are grown, they will soon perish. This is the case, because there is then nothing present in the water to destroy the noxious matters which are given off by them in their respiration and other processes, and thus they perish by their own action upon the medium in which they are placed. In Nature, we always find plants existing with animal life in the water, so that the injurious influence communicated by the latter to that medium, is counteracted by the respiration of the former. This compensating influence of plants and animals is beautifully illustrated in our vivaria. Hence we see the importance again, in our sanitary arrangements, of bearing in mind these effects of plants ; for we are taught by them, that it is absolutely necessary, if we desire to maintain a large town in a healthy state, to set apart large areas and plant them freely, for by such means, we not only maintain the purity of the air, but also, at the same time, afford spaces for exercise and recreation.

Let me here briefly notice a widely-spread notion, that plants, when grown in rooms where there is but little ventilation, and, therefore, especially in our sleeping apartments, have an injurious influence upon the air contained in them. This idea has arisen from the circumstance of plants, when not exposed to solar light, having a contrary effect upon the atmosphere to that which they have when submitted to its influence ; that is to say that they then absorb oxygen and give off carbonic acid gas, instead of absorbing carbonic acid gas and giving off oxygen. The amount of carbonic acid gas, however, which is then given off by plants is so extremely small, that it can have no sensible

effect upon the atmosphere in which they are placed. It might be readily shown that it would require some thousands of plants, in this way, to vitiate the air of a room to anything like the extent of that of a single animal, and that, therefore, the idea of a few plants rendering the air of close rooms unwholesome by this action, is altogether erroneous. It is certain, however, that the odours of plants may affect injuriously, to some extent at least, certain individuals of delicate organization or peculiar idiosyncrasies.

When leaves are not green, as is the case in many parasitic plants; and in those which are more or less blanched, they, like the other parts of a plant in a similar condition, exhale carbonic acid.

4. *Formation of the Products and Secretions by Leaves.*— By the changes produced in the watery contents of the green leaves by exposure to air and light, as noticed in the three preceding sections, the materials which they then contain are in a very active chemical condition, and freely combine together, by which various substances are formed, such as starch, sugar, gum, proteine matters, &c., which are directly concerned in the growth and nutrition of the plants in which they are found; as well as others, such as resinous matters, various acids, numerous alkaloids, colouring matters, &c., which, as far as we know at present, perform no further active part in the plant, and are acccordingly removed from the young and vitally active parts, and either stored up in the older tissues of the plants as *secretions*, or removed altogether from them as *excretions*. The production of these substances is commonly termed Assimilation. We see, therefore, that without leaves or other analogous green organs, no growth to any extent could take place, or any peculiar secretions be formed; and that without the exposure of even the leaves to light, no proper assimilation of the various matters taken up by the plant could take place; and hence, if a plant be put into the dark, it becomes blanched (*etiolated*), in consequence of the non-development of chlorophyll, and that, moreover, no woody matter is then formed, and but few of the peculiar secretions. The effect of the absence of light upon plants, is well shown, when a potato tuber sprouts in the dark ; in which case the whole of its tissues are seen to become etiolated, and ultimately to die ; or when potatoes are reared under a diminished supply of light, as when they are grown in an orchard, or under trees, under which circumstances, the tubers are what is called watery, in consequence of the small quantity of starch then produced. Another illustration of the effect produced by the absence of light is afforded in growing certain vegetables for the table, such as Sea-Kale, Celery, &c. In these latter instances, when the plants are grown freely exposed to light, they form abundance of woody matter, which renders them

tough or stringy; and also peculiar secretions, which are either unpleasant to the taste or absolutely injurious. The formation of these secretions and woody matter is prevented when light is more or less absent, and hence such then become useful vegetables.

How such a vast variety of compound substances can be formed in such simply organised bodies as plants are, at present we know but very little. It is to the combined labours of the chemist and physiologist that we must look for the elucidation of this important matter, but it is not our purpose to allude here to the various theories that have been entertained upon their formation and nature, but we must refer the reader who wishes to become acquainted with this subject, to Mulder's "Physiological Chemistry," as translated by Fromberg and Johnston, in which he will find full details.

5. *Effects of Gases generally upon Leaves.*—In the last section we have seen, that the ordinary normal constituents of atmospheric air, namely, carbonic acid, oxygen, nitrogen, and ammonia, in certain proportions, are those which are especially necessary for the due elaboration of the various products and secretions of plants, and these we have now shown are absorbed by the leaves or roots. It is by leaves especially, that carbon, which is so essential to plants, and which enters so largely into the composition of its various products and secretions, is absorbed. It must be understood, however, that plants will not live in an atmosphere composed simply of either carbonic acid, oxygen, or nitrogen; but that for their proper development, these gases must be mixed in suitable proportions; for if either of them be in great excess, the plants will either languish or perish, according to circumstances. Plants will, however, flourish in an atmosphere containing a moderate addition of carbonic acid, even more vigorously than in ordinary atmospheric air; but if the amount be considerably increased, they will perish. This injurious effect of carbonic acid, when in excessive quantities, would seem to be owing to a directly poisonous influence which is then exerted by it upon them. When plants are placed in pure nitrogen or oxygen, or under any other circumstances where they cannot obtain a suitable supply of carbonic acid, they soon decay.

Whilst the above gases in suitable proportions are necessary to the due performance of the proper functions of plants, other gases when mixed in the air in which they are placed, act more or less injuriously upon them. This is more particularly the case with sulphurous acid and hydrochloric acid gases, even in small quantities; but atmospheres containing much ammonia, common coal gas, cyanogen, &c., also act prejudicially. The action of sulphurous and hydrochloric acid gases upon plants appears to resemble that of irritants upon animals, for they first exert a local action upon the extremities of the leaves, and then

this influence is communicated into the deeper tissues, and if the plants be not removed into a purer air, they perish; but when such gases are not in great quantities, if the plants are speedily removed from their influence, they usually revive, the parts attacked alone being permanently injured.

While such gases act as irritant poisons upon plants, sulphuretted hydrogen, carbonic oxide, common coal gas, cyanogen, &c., seem to exert an influence upon plants like that produced by narcotic poisons upon animals, for by their action an injurious influence is produced generally on their vitality, and a general drooping of the leaves, &c., takes place, and when such is the case, no after removal into a purer air will cause them to revive.

As the above gases are constantly present in the air of large towns, and more especially in those where chemical manufactories are going on, we have at once an explanation of the reason, why plants submitted to such influences will not thrive. The air of an ordinary sitting room, and more especially where gas is burned, is also rendered more or less unsuitable to the healthy growth of plants, in consequence of the production of injurious gases. The dryness of the atmosphere, and the consequent excessive transpiration from the leaves, is also another cause which prevents plants growing vigorously in such situations.

Wardian Cases.—In order to protect plants from the injurious influences thus exerted upon them by the soot and air of large towns, &c., Mr. N. B. Ward, some years since, introduced a plan of growing them under closed glass cases, which has been found to succeed admirably. These cases consist simply, of a box or trough in which a suitable soil is placed; in this the plants are put, and the whole is covered by a closely fitting glass case. It is necessary, at first, to water the plants freely. When plants are grown under such circumstances, upon exposure to light and air, transpiration takes place from their leaves, as under ordinary conditions of growth; the fluid thus transpired is, however, here condensed upon the surface of the glass case which encloses the plants; this ultimately returns to the soil, and is thus brought into contact again with the roots of the plants, to be again absorbed and exhaled by them; and these changes are continually repeated, so that the plants are always freely exposed to moisture, and do not require a further supply of water for frequently a considerable period. Those plants especially, which succeed best in a damp atmosphere, as is commonly the case with Ferns, do exceedingly well in such cases. The most important influence, however, which is exerted by such cases is, the protection of the plants from the immediate contact with the air impregnated with soot and other injurious substances; for in consequence of the glass cover fitting closely to the trough in which the plants are placed, the external air in its passage to them, has to pass through the very narrow crevices beneath the

cover, and in so doing, becomes filtered, as it were, in a great measure, from its impurities, before it is brought into contact with them.

Besides the use of these cases in growing plants luxuriantly, in those places where, under ordinary circumstances, they would perish, or at all events grow but languidly, they have a still more important application, for they have now been most successfully employed in transporting plants from one country to another, which under ordinary circumstances would have died in their transit, and whose seeds could not be transported either without losing their vitality.

The action of the Wardian cases in this mode of transporting plants is twofold; thus, in the first place, the plants are protected from the influence of salt breezes, which are in most instances very injurious to plants; and secondly, the atmosphere of such cases remains in a quiet state, and by this means the plants are protected from all rapid changes of temperature.

6. *Colour of Leaves.*—The green colour of leaves is due to chlorophyll contained in the cells situated beneath the epidermis. Chlorophyll, as already noticed (see page 20), is only formed under the influence of light, and hence the leaves of plants grown in darkness are blanched or etiolated (page 741). If plants with green leaves be withdrawn from the action of light, and be placed in the dark, these leaves soon fall, and if others are produced, they have a whitish or yellowish colour. Again, if plants, which have been grown in the dark, be removed to the light, the leaves upon them soon lose their whitish hue and become green. The rapidity with which leaves become green, and the intensity of the colour, will be in proportion to the amount of light to which they have been exposed.

The different rays of the spectrum have a varying influence in promoting the formation of chlorophyll. Some difference of opinion exists as to those rays which are most active in this respect, but the majority of experimenters agree, that the illuminating or yellow rays, namely, those which, as we have already seen (page 738), have the greatest effect in promoting the decomposition of carbonic acid, are those also which are the most active in the production of chlorophyll.

M. Frémy has recently made some important investigations upon chlorophyll. He has ascertained that it is composed of two colouring principles, — one a yellow, which he has termed *phylloxanthine;* and the other a blue, which he has called *phyllocyanine.* Both these principles have been isolated by M. Frémy. M. Frémy has also endeavoured to show, that the yellow colour of etiolated and very young leaves, is due to the presence of a body, which he has termed *phylloxanthéine*, and which is coloured blue by the vapour of acids. The same principle results from the decoloration of phyllocyanine; hence, it would

seem, that phyllocyanine is not an immediate principle, but that it is formed by the alteration of phylloxanthéine. The more recent experiments of M. Filhol do not, however, altogether correspond with those of M. Frémy.

The autumnal tints of leaves, which are generally some shades of yellow, brown, or red, are commonly regarded as due to varying degrees of oxidation of the chlorophyll which their cells contain. The experiments of M. Frémy show, that the yellow leaves of autumn contain no phyllocyanine, and hence that their colour is entirely due to the phylloxanthine, either in its original condition or in an altered state.

When leaves are of some other colour than green, the different colours are produced, either, by an alteration of chlorophyll or of one of the principles of which it is formed; or in consequence of the presence of some other colouring principle.

Variegation in leaves must be regarded as a diseased condition of the cells of which they are composed; it is commonly produced by hybridization, grafting, differences of climate, soil, &c. The variegated tints are due, either to the presence of air in some of the cells; or more commonly, to an alteration of the chlorophyll of certain cells, or of one of the substances of which the chlorophyll is composed.

7. *Defoliation, or the Fall of the Leaf.*—After a certain period, which varies in different plants, the leaves either die upon the stem upon which they are placed before they fall, as is the case commonly in those of Monocotyledonous and Acotyledonous plants (see page 184), and also in some Dicotyledonous ones (page 174); or they separate from the stem by means of an articulation or joint when they have performed their active functions, or even sometimes when quite green. In the former case the leaves are non-articulated; in the latter articulated. In the trees of this and other temperate climates the leaves commonly fall off the same year in which they are developed, that is, before the winter months; and in those of warm and tropical regions the fall of the leaf often takes place at the dry season. The leaves of other plants, however, generally remain for two or more years. In the former case they are annual or deciduous, and in the latter persistent. The fall of the leaf is commonly termed *defoliation*.

The cause or causes which lead to the fall of the leaf are by no means well understood. The opinion commonly entertained is this: the cells of the leaf contain various inorganic matters dissolved in their liquid contents, and therefore, as exhalation of watery matters proceeds, the membrane constituting their walls, gradually become incrusted by the deposit of earthy matters which are left behind, until ultimately, the tissues of the leaf become choked up with such deposits, and are no longer able to perform their proper functions. The leaf then begins to dry up, its attachment to the stem becomes weakened, and it ulti-

mately falls off, either by its own weight, or in consequence of the subsequent increase of the stem upon which it is placed, or by the operation of external causes.

According to Dr. Inman, the fall of the leaf in those cases where no articulation exists "is not an accidental occurrence, arising from vicissitudes of temperature and the like, but a regular and vital process which commences with the first formation of the organ, and is completed only when that is no longer useful." Asa Gray thus describes it:—"The formation of the articulation is a vital process, a kind of disintegration of a transverse layer of cells, which cuts off the petiole by a regular line, in a perfectly uniform manner in each species, leaving a clean scar (*figs.* 193 and 349 *f*), at the insertion. The solution of continuity begins at the epidermis, where a faint line marks the position of the future joint while the leaf is still young and vigorous; later, the line of demarcation becomes well marked, internally as well as externally; the disintegrating process advances from without inwards until it reaches the woody bundles; and the side next the stem, which is to form the surface of the scar, has a layer of cells condensed into what appears like a prolongation of the epidermis, so that when the leaf separates," as Inman says, "the tree does not suffer from the effect of an open wound." Gray, then quoting Inman, adds:—"The provision for the separation being once complete, it requires little to effect it; a desiccation of one side of the leaf-stalk, by causing an effort of torsion, will readily break through the small remains of the fibro-vascular bundles; or the increased size of the coming leaf-bud will snap them; or, if these causes are not in operation, a gust of wind, a heavy shower, or even the simple weight of the lamina, will be enough to disrupt the small connections and send the suicidal member to the grave. Such is the history of the fall of the leaf."

8. *Development of Leaves.*—This subject has been already alluded to. (See p. 184.)

Having now briefly alluded to the special functions of the elementary structures, and of the organs of nutrition, we proceed in the next place to treat of the special functions of the organs of reproduction, but those who may desire to finish the description of the life of the nutritive organs, may pass at once to Chapter 2, which treats of the General Physiology of the Plant.

Section 3. — Physiology of the Organs of Reproduction.

1. Functions of Bracts and Floral Envelopes.—One of the principal offices performed by these organs is, to protect the young and tender parts placed within them from injury. When green, their colour is due to the presence of chlorophyll in their

component cells, and when in this state, as is commonly the case with the bracts and the parts of the calyx, they perform the same functions as ordinary leaves. When coloured, however, as is generally the case with the corolla, and occasionally with the bracts and calyx, they appear to have, in conjunction with the receptacle or thalamus, a special function to perform; which consists in the formation of a saccharine substance from the amylaceous matter stored up in them. This saccharine matter is designed more especially for the nourishment of the essential organs of reproduction. That such is the function of these parts seems to be proved by the varying composition of the thalamus at different periods of the flowering stage. Thus, at the period of the opening of the flower, the thalamus is dry and its cells are filled with amylaceous matters; as flowering proceeds, these matters become converted into saccharine substances, upon which the surrounding parts are nourished; and finally, after flowering it dries up. In fact, a similar change takes place in the process of flowering in the composition of the contents of the surrounding parts, as in the process of germination, where the amylaceous matters are in like manner converted into saccharine.

When the saccharine matter is in excess during the process of flowering, it is found npon the parts in a liquid state, and may be removed without the flower suffering therefrom.

In this conversion of amylaceous into saccharine matter, oxygen is absorbed from the atmosphere, and carbonic acid gas given off in a corresponding degree. Hence, the action of the coloured parts of the flower or those not green, upon the surrounding air, is directly the reverse of that of the green leaves and other green organs whilst under the influence of solar light. The absorption of oxygen thus noticed as occurring in the coloured floral envelopes, also takes place in a still greater degree in the essential organs of reproduction; hence, such an effect is more evident in perfect flowers, than in those in which the stamens and carpels have been more or less changed into petals — that is, when the flowers have become partially or wholly double. It has been proved also, that staminate flowers absorb more oxygen than pistillate ones.

The combination which under the above circumstances takes place between the carbon of the flower and the oxygen of the air, is attended by an evolution of heat, which indeed is always the case where active chemical combination is going on. This evolution of heat in the majority of flowers is not observable, because it is immediately carried off by the surrounding air; but in those cases, where many flowers are crowded together, and more especially when they are surrounded by a leafy structure, such as a spathe, which confines the evolved heat, it may be readily noticed. The flowers of the male cone of *Cycas circi-*

nalis, those of the *Victoria regia*, of several *Cacti*, and of many *Araceæ*, present us with the most marked illustrations of rise of temperature.

That this evolution of heat is dependent upon the combination of the oxygen of the air with the carbon of the flower, was conclusively proved by the experiments of Vrolik and Vriese ; for they showed that the evolution of heat by the spadix of an Arum, is much greater when it is placed in oxygen gas than in ordinary atmospheric air ; and that when introduced into carbonic acid or nitrogen gases, it ceased altogether.

2. Of the Essential Organs of Reproduction.—*Sexuality of Plants.*—The stamens of flowering plants, as has been already repeatedly stated, constitute the male apparatus, and the carpels the female. That the influence of the pollen is necessary to the formation of perfect seed may now be considered as positively established in an immense majority of flowering plants ; and although certain apparent exceptions occur, which we find it impossible to explain in the present state of our knowledge, where perfect seeds have been produced without the agency of pollen, still such isolated cases must not be allowed to overthrow the great mass of evidence which may be adduced to show, that some pollinic influence is generally essential to the production of a seed with a perfect embryo. It would appear from various observations, that a kind of Parthenogenesis takes place in some plants, and hence, that a single impregnation is sufficient to produce several generations.

While the presence of two distinct sexes may thus be shown in flowering plants, both of which are necessary for the formation of perfect seed ; it seems almost certain that flowerless plants, in like manner, possess certain organs, which represent the two sexes of flowering plants, and that their functions are accordingly, essentially the same. It is quite true that the existence of sexuality has not been proved in all the Cryptogamia, but as it exists in the greater number, we may fairly conclude from analogy that it is present in all. (See *Structure of the Reproductive Organs of Flowerless Plants*, pp. 367—393.)

SEXUAL REPRODUCTION OF PLANTS.

We have just stated, that a seed is only to be considered perfect when it contains an embryo which is capable of germinating and producing a new plant; and that for its formation the mutual influence of two sexes is necessary, as has been conclusively shown in an immense majority of flowering plants, and hence we conclude from analogy that such an influence is necessary in all.

In flowerless plants, also, as noticed above, the influence of two sexes has been shown to be necessary in the majority of

cases, and hence we may also fairly conclude that it is necessary in all, although not absolutely proved. Flowerless plants, however, have no true seeds containing an embryo, but are propagated by spores (page 367), which either reproduce the plant directly, or give rise to an intermediate body, called the *pro-embryo* or *pro-thallus* (*fig.* 784, *p*), from which the fructiferous or fruit-bearing plant ultimately springs (see page 368). Much difference of opinion has arisen of late years, amongst botanists, as to the mode in which reproduction takes place in the different divisions of the vegetable kingdom. The detailed discussion of these different views would be incompatible with the object of an elementary manual of botany, and we shall content ourselves, therefore, with a general summary of the more important conclusions which appear to be most in accordance with our present knowledge upon so difficult a subject.

1. Reproduction of Cryptogamous or Acotyledonous Plants.—We have already described the structure of the reproductive organs of these plants (see pp. 367—393), and in doing so, we treated of them in two divisions, called respectively, Acrogens and Thallogens, each of which was again sub-divided into several natural orders. We shall follow the same arrangement in describing their modes of reproduction, except, that we shall here commence with the Thallogens, and proceed upwards to those plants of a more complicated nature, instead of alluding to them, as we then did, in an inverse order.

A. Reproduction of Thallogens.—The sexuality of plants in all the natural orders of Thallogens has not been absolutely proved, but only concluded by analogy. In the Algæ alone, have sexes been clearly shown to exist. The reproductive organs of Fungi and Lichens having been already described, and as nothing is positively known as to the mode in which they are reproduced, it will only be necessary for us to give a summary of the modes of reproduction in the Algæ or Sea-weeds.

Reproduction of Algæ. — The existence of sexes has been proved in members of all the sub-orders of Algæ, although the actual impregnation of the female corpuscle has only been directly observed in four of them, namely, in the Volvocineæ, Diatomaceæ, Chlorosporeæ, and Melanosporeæ.

The fecundation of Algæ takes place in two very distinct ways, namely, by *conjugation*, and by the direct *impregnation of naked spores or germ corpuscles by ciliated spermatozoids.* Each mode is also subject to modifications. We can only briefly allude to the subject here.

1. *Conjugation.*—This process has been noticed in the Diatomaceæ generally, and in certain Chlorosporeæ. It consists in the union of the contents (*endochrome*) of the cells of two filaments (fronds), (*fig.* 828), and the formation of a germinating spore by their mutual action. No difference can be detected in

the structure of the conjugating cells, previous to impregnation.

Two methods of conjugation may be noticed, one, which occurs generally in the Diatomaceæ, and the other in certain of the Chlorosporeæ. In the first mode (*figs.* 1096 and 1101), two

Fig. 1101.

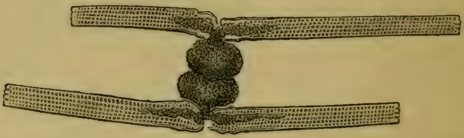


Fig. 1101.—Two Desmidiaceous Algæ (*Docidium Ehrenbergii*), in process of conjugating. The contents of the two are seen to be intermingling in the intervening space, and are at present only invested by a primordial utricle. After Ralfs.

individuals, each of which is composed of a single cell, approach one another, the external cellulose membranes bounding their respective cells burst, and the contents of the two, invested by a primordial utricle, issue from the orifices thus produced (*fig.* 1101), intermingle in the intervening space, and form ultimately, by their mutual action, a rounded body (*fig.* 1096), called a *resting* or *inactive* spore, which ultimately germinates. The contents of the spore are green and granular at first, but ultimately become brown, yellow, or reddish. These resting spores, which are furnished with two coats (*fig.* 1096), are sometimes called sporangia, because they ultimately produce two or more germs in their interior, and are not therefore simple spores.

In the other mode of conjugation, which occurs in certain Chlorosporeæ, as in *Zygnema* (*fig.* 828), the cells of two filaments develop on their adjoining sides a small tubular process; these ultimately meet, and adhere, and the intervening septum existing at the point of contact becoming absorbed, the two cells freely communicate together. The contents of the cells then contract into a mass, and ultimately combine together, either by the passage of the contents of one cell into the other, or by the mixture of the contents of the two cells in the tubular process between them. Under either circumstance, the mixture of the contents of the two cells results in the formation of a *resting spore*, which ultimately germinates into an individual resembling its parents.

2. *Impregnation of naked spores or germ-corpuscles by ciliated spermatozoids.* — This mode of fecundation has been observed in some of the Chlorosporeæ, in Volvocineæ, and in Melano-

sporeæ, and probably occurs also in the Rhodosporeæ. There appear to be two modes in which such fecundation occurs in the above; thus, in the Volvocineæ, and in certain Chlorosporeæ, the fecundation takes place before the spore has separated from its parent; and in the Melanosporeæ, after both the spore and ciliated spermatozoids have been discharged.

As an illustration of *the first mode of fecundation* we may take *Vaucheria.* It is thus described by Henfrey:—"This plant is commonly propagated by a peculiar kind of zoospore (*fig.* 830, *g*), discharged from the thickened end of the filament or its branches. But at certain epochs lateral structures are developed at the sides of the filaments, as branch-cells, which become shut off from the main tube by septa; some of these processes expand into ovate and beaked, or bird's-head-shaped bodies, others into short curled filaments or 'horns.' The former are *sporangia*, the latter *antheridia.* When ripe, the *antheridia* or 'horns' discharge their cell-contents in the form of numerous spindle-shaped corpuscles, moving actively by the help of a pair of cilia. Meanwhile an orifice is formed in the beak of the sporangium, and some of the spermatozoids make their way in, so as to come into direct contact with the cell-contents. This phenomenon is followed by the closing up of the sporangium by a membrane, and the conversion of its contents into a fertile *resting spore.*" This process is subject to various modifications in the other genera in which it occurs.

The second mode of fecundation of naked spores by ciliated spermatozoids, occurs in the Melanosporeæ, and has been especially investigated by Thuret. His observations have been thus condensed by Henfrey:—"In this order the *conceptacles* (*fig.* 837) produce in their interior, bodies of two kinds, *antheridia* (*figs.* 838, and 839, *a*, *a*, *a*) and *spore-sacs* (*fig.* 837, *sp*), either together or in separate conceptacles (monœcious), or in separate plants. The antheridia discharge 2-ciliated *spermatozoids* (*fig.* 838), which are poured out through the pores of the *receptacles* (*fig.* 153, *t*) into the surrounding water. At the same time the spore-sac (*fig.* 837, *sp*) bursts, and emits an inner sac, in which may be observed 2, 4, or 8 spherical corpuscles, destitute of a cellulose membrane; this inner sac breaking loose, bursts and discharges its corpuscles, which, like the spermatozoids, pass through the pores of the receptacle into the water. Here they become surrounded by a cloud of spermatozoids which attach themselves to the surface, and by their ciliary movement cause the spores to revolve. In the course of a few minutes usually, a cellulose membrane is formed upon the surface of the globular corpuscle (by secretion from its primordial utricle ?) and it becomes a cell, which subsequently germinates, growing by cell-division into a new frond."

B. Reproduction of Acrogens. — Of the sexual nature of the

plants in all the orders of this sub-division of the Cryptogamia, there can be no doubt, although the actual process of fecundation has only been clearly observed in the Filices. The sexual organs in all are also of an analogous character, and are of two kinds, one of which is termed an *antheridium*, which contains spirally wound ciliated spermatozoids, and which is regarded as the male organ; and the other, called an archegonium or pistillidium, in which an embryonal cell or germ-cell is contained, which appears to be the female organ. Fecundation is supposed to take place by the contact of a spermatozoid with an embryonal cell or germ-cell. In the Characeæ no distinct archegonium occurs, but the nucule is considered as the representative of that structure. We have already described the structure of the reproductive organs of Acrogens (pp. 368—382), both before and after fecundation; it will be only necessary therefore, in the present place, to say a few words upon the mode in which fecundation is supposed to take place in the different natural orders included in this division of the Cryptogamia.

1. *Characeæ or Charas.*—In this order we have two kinds of reproductive organs, called respectively, the *globule* (*fig.* 813, *g*), and the *nucule* (*fig.* 813, *n*); the former is regarded as the *male*; and the latter as the *female*. Fecundation is believed to take place, by the passage of the spermatozoids of the globule (*fig.* 814) down the canal which extends from the apex of the nucule (*figs.* 816 and 817) to the central cell of the same structure, which then becomes fertilized. No free spore is, however, produced, but the nucule then drops off, and after a certain period germinates in a manner closely resembling the seed of a monocotyledonous plant, by which a new plant is at once formed without any intermediate pro-thallus being produced.

2. *Hepaticaceæ or Liverworts.*—The reproductive organs of this order closely resemble those of Mosses. They are termed *Antheridia* (*figs.* 808 and 809) and *Archegonia* or *Pistillidia* (*figs.* 810 and 811), the former representing the male sex, and the latter the female. When the antheridium bursts (*fig.* 809), it discharges a number of small cells which also burst, and each emits a very small 2-ciliated spiral spermatozoid. These spermatozoids are supposed to pass down the canal of the archegonium (*fig.* 811) to the germ or embryonal cell which is situated at its bottom, which thus becomes fertilized. This cell after fertilization undergoes various important changes, as already noticed (see p. 380), and ultimately becomes a sporangium enclosing spores. When these spores germinate, they generally produce a sort of confervoid structure or mycelium (*pro-thallus*), which in its after development resembles the like structure of Mosses (*fig.* 1102).

3. *Musci or Mosses.*—The reproductive organs of this order consist of *antheridia* (*fig.* 799) and *archegonia* (*fig.* 800), which

closely resemble the same structures of the Hepaticaceæ. Fertilization takes place in a similar manner to them (see p. 752), and the changes which take place after fertilization in the embryonal cell which ultimately forms a sporangium containing spores (*fig.* 807) have been already described. (See p. 376.)

In germination, the spore forms a green, cellular, branched mass or *pro-thallus*, resembling a Conferva. This structure is sometimes termed *protonema* (see p. 378). Upon the threads of this structure (*fig.* 1102), buds (a) are ultimately produced, which grow up into leafy stems (b), upon which archegonia and pistillidia are afterwards developed.

Fig. 1102.

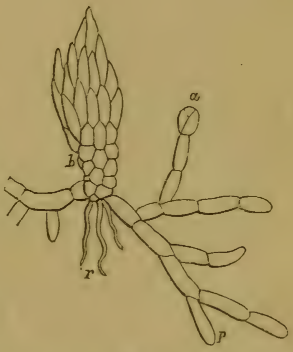


Fig. 1102. *Pro-thallus* or *protonema* of a Moss (*Funaria hygrometrica*). *p.* Confervoid protonema; *a.* Bud; *b.* Young leafy stem; *r.* Rootlets.

4. *Lycopodiaceæ or Club-Mosses.*—The two reproductive organs of this order are termed *oosporangia* or *oophoridia* (*figs.* 795 and 798), which represent the female; and *antheridia* or *pollen-sporangia* (*figs.* 796 and 797), which are regarded as male organs. The contents of the pollen-sporangium are called *small spores* (*microspores*), in which cells enclosing spermatozoids are contained (*fig.* 1103 c); those of the oosporangia are termed *large spores*, *macrospores*, or *megaspores* (*fig.* 798).

In germination, the macrospore produces a pro-thallus in its interior (*fig.* 1104, p), on which archegonia (*fig.* 1105, a) are subsequently developed. Each archegonium (*fig.* 1105, a) consists of an intercellular canal leading into a sac below, which contains a single germ or embryonal cell. Fertilization is considered to take place by the spermatozoids contained in the microspores (*fig.* 1103, c), passing down the canal of the archegonium and coming into contact with the germ-cell. This cell then grows by cell-division and forms the *embryo* (*fig.* 1105, e), which in *Selaginella* grows down into the pro-thallus (*fig.* 1105), and ultimately produces a new leafy sporangiferous stem.

5. *Marsileaceæ or Pepperworts.*—The two reproductive organs of this order are generally distinguished as *antheridia* (*figs.* 791 and 794, a) and *pistillidia sporangia* or *ovules* (*figs.* 792 and 794, b). These two structures are either contained in separate sacs, as in *Salvinia* (*fig.* 794); or in the same, as in *Marsilea*

(*fig.* 790). The antheridia contain a number of small cells called generally *pollen-spores* or *small spores* (*fig.* 791), which

Fig. 1103.

Fig. 1104.

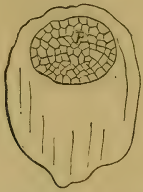


Fig. 1105.

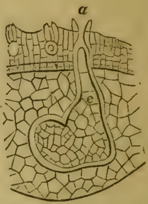


Fig. 1103. *Small spore*, *pollen-spore*, or *microspore*, of a species of *Selaginella*, bursting and discharging small cells, *c*, in which spermatozoids are contained.——*Fig.* 1104. *Large spore*, *macrospore*, or *megaspore*, of a species of *Selaginella*. The outer coat of the spore has been removed to show the entire inner coat, with the young pro-thallus, *p*, at the upper end.——*Fig.* 1105. Vertical section of a portion of the pro-thallus of the above in a more advanced state, showing the archegonia. *a*. Archegonium, in which the embryo *e*, has been developed from the germ-cell it contained, by contact with the spermatozoids. This embryo, by the growth of the suspensor, is forced downwards and imbedded in the upper part of the cellular mass of the spore-sac.

enclose spermatozoids (*fig.* 1106). The pistillidia sporangia (*fig.* 794, *b*) contain commonly but one spore (*fig.* 792), called an *ovulary spore*, *large spore*, or *megaspore*. In their organs of fructification the plants of this order closely resemble the Lycopodiaceæ (see p. 374). Like the Lycopodiaceæ also, the large spores produce a pro-thallus in their interior (*fig.*

Fig. 1106.

Fig. 1107.

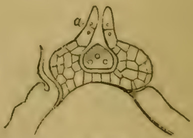


Fig. 1106. *Pollen-spore*, *small spore*, or *microspore*, of Pill-wort (*Pilularia globulifera*), bursting and discharging small cells enclosing spermatozoids. Some of the latter may be observed to have escaped by the rupture of the small cells in which they were contained.——*Fig.* 1107. Vertical section of the pro-thallus of the above, which is formed, as in the Lycopodiaceæ, in the interior of the *large spore* or *megaspore*. Only one archegonium, *a*, is here produced in the centre. The archegonium consists of an intercellular canal, leading into a sac below, in which may be seen a solitary *germ* or *embryonal cell*.

1107), in which subsequently only a single archegonium generally appears (*fig.* 1107, *a*), as in *Pilularia* and *Marsilea*, although in *Salvinia* there are several archegonia formed. Im-

pregnation takes place by the contact of the spermatozoids with the germ-cell of the archegonium, which immediately developes and forms the embryo, from which a leafy stem bearing fructification is ultimately produced.

6. *Equisetaceæ or Horse-tails*, and

7. *Filices or Ferns*.—The mode of reproduction of the plants of these two orders is essentially the same, and we shall accordingly allude to them together. As already fully noticed (see pp. 369—372), their leafy structures bear sporangia in which the spores are enclosed (*figs*. 783 and 787—789). There is, however, but one kind of spore.

The germination of these spores has already been noticed (p. 369), but it will be better for us to refer to it again in this place. In germination, these spores form ultimately a thin, flat, green parenchymatous expansion (*figs*. 784 and 1108, *b*), which somewhat resembles the permanent thallus of the Hepaticaceæ (*figs*. 808 and 810). Upon the under surface of this structure we have ultimately formed, in the *Filices*, both *antheridia* and *archegonia;* but in the *Equisetaceæ*, the antheridia and archegonia have only been found on separate pro-thalli, and hence these plants would appear to be diœcious. The antheridia (*fig*. 785) contain a number of minute cells called *sperm-cells* (*se*), each of which contains a spirally wound ciliated spermatozoid (*sp*). The *archegonium* (*fig*. 786), is a little cellular papilla, having a central canal, which when mature is open. At the bottom of the canal is a cell called the *embryo-sac*, in which a *germ-cell* or *embryo-cell* is developed. According to other observers, this so-called embryo-cell is simply a germinal corpuscle till after fertilization,—that is, a free primordial utricle, without an external wall of cellulose.

Fig. 1108.

Fig. 1108.—*a*, young sporangiferous plant of a species of Fern (*Pteris*) arising from an embryo produced by impregnation in the archegonium of the pro-thallus, *b*.

When mature, the upper part of the antheridium separates from the lower, something like the lid of a box; the sperm-cells then escape, become ruptured, and emit their contained spermatozoids. These spermatozoids make their way down the canal of the archegonium to the embryo-sac, by which the contained germ-cell, embryo-cell, or germinal corpuscle, is fertilized. This embryo-cell then developes, and the embryo thus formed continues to increase, and soon possesses rudimentary leaves and roots (*fig*. 1108), and ultimately produces a plant with fronds bearing sporangia, which resembles the one from which the spore was originally obtained. The Ferns and Horse-tails, as already noticed (pp. 371 and 372), are thus seen to exhibit two stages in their growth; in the first of which the spores produce a thalloid ex-

pansion; and in the second, by the development of antheridia and archegonia upon the surface of this pro-thallus, by the action of which there is ultimately produced a new plant, resembling in every respect the one from which the spore was originally derived. Hence Ferns and Horse-tails exhibit what has been termed *alternation of generations.*

2. Reproduction of Phanerogamous or Cotyledonous Plants.—In all the plants belonging to this division of the vegetable kingdom the *male apparatus* is represented by one or more stamens, each of which essentially consists of an anther enclosing *pollen-grains* (*fig.* 423, *p*); and the *female*, by one or more carpels (*figs.* 711—713), in or upon which (*fig.* 709), one or more ovules are formed. When the ovules are enclosed in an ovary, the plants to which they belong are called *Angiospermous;* but when they are only placed upon metamorphosed leaves or open carpels, the plants are said to be *Gymnospermous.* In the plants of both these divisions of the vegetable kingdom, the ovules by the action of the pollen are developed into perfect seeds whilst connected to their parent,—the distinguishing character of that seed from a spore being the presence of a rudimentary plant called the embryo. The modes in which reproduction takes place, and the after development of the embryo, differ in several important particulars in Gymnospermous and Angiospermous plants; hence it is necessary to describe them separately.

1. *Reproduction of Gymnospermia.*—We have already given a general description of the pollen and ovules, but as these structures present certain differences in the Gymnospermia from those found in the Angiospermia, it will be necessary for us to allude to such peculiarities before describing the actual process of reproduction.

The *pollen* of the Phanerogamia generally,—that is of the Angiospermia, consists, as we have seen (p. 359), of a cell containing a matter called the *fovilla*, and having a wall which is usually composed of two coats, the outer of which is termed the *extine*, and which possesses one or more pores (*fig.* 556), or slits (*figs.* 554 and 555), or both; and the inner, called the *intine*, which is destitute of any pores or slits, and consequently forms a completely closed membrane. Each pollen-grain of the Angiospermia is thus seen to be a simple cell. In the Gymnospermia, on the contrary, the pollen-grains are not simple cells, but they contain other small cells, which adhere to the inside of the internal membrane close to the point where the external membrane presents a slit.

The ovules of the Gymnospermia, excluding those of the Gnetaceæ which require further investigation, consist of a nucleus (*fig.* 1109, *a*), enclosed by a single coat, and with a large micropyle, *m.* Before the contact of the pollen with the micro-

pyle of the ovule, the primary embryo-sac, (*b*,) is developed in the nucleus. This embryo-sac is at first very small (*fig.* 1109, *b*), but gradually enlarges (*fig.* 1110, *a*), and after a long period, becomes filled with delicate cells, called endosperm cells

Fig. 1109.

Fig. 1110.

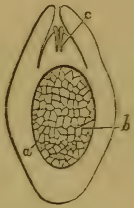


Fig. 1109. Vertical section of the young unimpregnated ovule of a species of *Pinus*. *a*. Nucleus containing a small primary embryo-sac, *b*. *m*. Micropyle, which is here very large.——*Fig.* 1110. Vertical section of an older ovule of a species of *Pinus*. *a*. Enlarged primary embryo-sac. *b*. Endospermal cells within the embryo-sac. *c*. Pollen-tubes penetrating the apex of the nucleus.

(*fig.* 1110, *b*). The subsequent development of the ovule, and the mode by which it is fertilized, is taken from Henfrey, and is founded upon Hofmeister's investigations.

"In the upper part of the mass of endosperm (*fig.* 1110, *b*), from five to eight cells are found to expand more than the rest, forming *secondary embryo-sacs*. These are not formed in the superficial cells of *b*, but from cells of the second layer, so that each is separated from the membrane of the primary embryo-sac by one cell (*fig.* 1111, A). Those cells lying between the *secondary embryo-sacs* and the surface of the endosperm, next undergo division cross-wise, so as to form a rosette of four cells, which separate at the converging angles, and leave a central intercellular passage down to the secondary embryo-sac (*fig.* 1111, B). In this state, these *corpuscula*, as they were called by R. Brown, their discoverer, are very much like the *archegonia* in the internal prothallium-structure of *Selaginella* (Lycopodiaceæ, p. 753, and *fig.* 1105)."

The process of fertilization takes place as follows : — "The pollen-grains fall at once upon the ovules and pass into the micropyle, (sending down their pollen-tubes here developed from the internal cellular body, which passes out through the proper coat of the pollen-cell,) through the substance of the upper part of the nucleus (*fig.* 1110, *c*), and reach the mouth of the canals of the *corpuscula*, one entering each (*fig.* 1111, B, *pt*). At the same time, *germinal corpuscles* are produced at the

base of the secondary embryo-sacs (*fig.* 1111 B, *a*). These, after fertilization, by the contact of the pollen-tube with the upper end of the sac (*pt*), become cells, multiply, and form a cellular mass, the lower cells of which break out through the bottom

Fig. 1111.

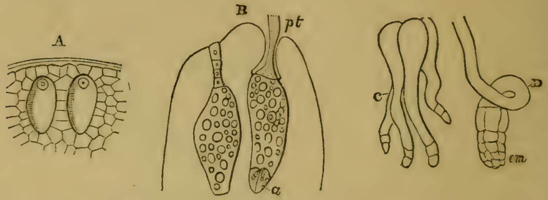


Fig. 1111. Development of the embryo in a species of *Pinus* (Coniferæ). After Henfrey. A. Upper part of the embryo-sac, with two secondary embryo-sacs, corpuscula, or archegonia. B. The same, more advanced. *pt*. Pollen-tube in the canal leading down to the corpuscula. *a*. Germinal corpuscles at the base of the secondary embryo-sac. C. Four cellular filaments or *suspensors*, which are developed from the germinal corpuscles after impregnation. D. One of these suspensors, with the embryo (*em*) at its apex.

of the endosperm, and grow as four cellular filaments (C), into the substance of the lower part of the nucleus of the ovule ; at the ends of these filaments, cell-division again occurs (D), and from the apex of one of these filaments (*suspensors*), is developed the embryo (D, *em*). As there are several corpuscles, and each produces four suspensors, a large number of rudimentary embryos are developed; but usually only one of all these rudiments is perfected. The embryo which is fully developed, gradually increases in size, and most of the structures above described disappear, so that the ripe seed exhibits a single embryo, imbedded in a mass of endosperm or albumen, the latter originating apparently from the nucleus of the ovule."

2. *Reproduction of Angiospermia.* — The structure of the pollen-grains of the Angiospermia have been already described, (see *Pollen*, and p. 756), and need not be further alluded to in this place.

The ovule has also been particularly noticed, and we shall now only recapitulate its component parts at the time when the pollen is discharged from the anthers, — that is, just before impregnation takes place. It then consists of a cellular nucleus (*fig.* 1112, *n*), enclosed generally in two coats, as in the present figure. Sometimes there is but one coat (*fig.* 717), and in rare cases the nucleus is naked, or devoid of any coat (*fig.* 715).

These coats completely invest the nucleus except at the apex, where a small opening or canal is left, termed the mi-

cropyle (*fig.* 1112, *m*). In the interior of the nucleus, but of various sizes in proportion to it, the embryo-sac (*fig.* 1112, *s*) is commonly seen. This sac is, however, liable to many modifications; thus, in some cases, as in the *Orchidaceæ* (*figs.* 1113 and 1114), the embryo-sac completely obliterates the cells of the nucleus by its development, so that the ovule consists

Fig. 1112.

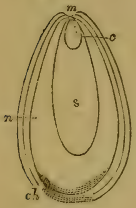


Fig. 1113.

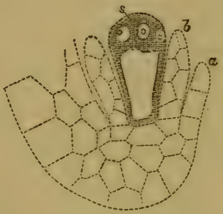


Fig. 1114.

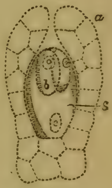


Fig. 1112. Vertical section of the orthotropous ovule of a species of *Polygonum*. *ch.* Chalaza. *n.* Nucleus invested by two coats. *m.* Micropyle. *s.* Embryo-sac. *c.* Germinal vesicle, or corpuscle.——*Fig.* 1113. The ovule, some time before fertilization. *a.* The outer coat. *b.* The inner coat. *s.* The embryo-sac, with three nuclei at the upper end.——*Fig.* 1114. The internal parts of the ovule a short time before fertilization. *a.* Inner coat of the ovule. *s.* Embryo-sac. *b.* Germinal vesicle. After Hofmeister.

simply of it and its two proper coats (*fig.* 1113, *a*, *b*). In the *Leguminosæ*, the embryo-sac increases still further, and causes the absorption of the secundine or inner coat of the ovule also, so that it is then simply invested by one coat (primine); while in other plants, as in the *Santalaceæ*, the sac elongates so much at the apex as to project out of the micropyle. The embryo-sac contains at first a more or less abundant quantity of protoplasm; in this nuclei afterwards appear (*fig.* 1113, *s*), which by the process of free-cell development, form a corresponding number of cells (usually three), which are commonly termed *germinal vesicles* (*figs.* 1112, *c*, and 1114, *b*). The vesicles are situated at or near the summit of the embryo-sac (*figs.* 1112, *c*, and 1114, *b*). Henfrey says, that these are not perfect vesicles with a cellulose coat before impregnation, but merely corpuscles of protoplasm, or rather free primordial utricles like the unfertilized spores of *Fucus* (p. 751). Hence he terms them *germinal corpuscles*, and applies the term germinal vesicle only to the impregnated corpuscle or rudimentary embryo. Whether these are simply corpuscles of protoplasm or true vesicles is therefore doubtful; but we shall in future, in accordance with the majority of writers, consider them as true vesicles before impregnation.

Such is the general structure of the unimpregnated ovule. Much difference of opinion has, until lately, existed amongst

physiologists, as to the contents of the embryo-sac previous to impregnation. Schleiden, Schacht, and others, contended, that no germinal vesicle existed in the sac until after the contact of the pollen-tube with it in the ordinary process of impregnation; in fact, they believed that, the germinal vesicle was itself formed from the end of the pollen-tube, which, according to their observations, penetrated the wall of the sac, and by subsequent development produced the embryo. If such had been proved to be true, the sexuality of Phanerogamous plants would have been shown to be incorrect; but such a view was at once combated by many accurate observers, who all agreed in describing the presence of one or more germinal vesicles or corpuscles in the sac before impregnation. Indeed, Schleiden himself, who originated this view of the origin of the embryo, has been convinced of his error, by Raddlkofer, one of his own distinguished pupils, so we may now consider the point as settled.

When the pollen falls upon the stigma, (the tissue of which at this period, as well as that forming the conducting tissue of the style and neighbouring parts, secretes a peculiar viscid fluid [p. 272]), its intine protrudes through one or more of the pores or slits of the extine (*fig.* 561) in the form of a delicate tube, which penetrates through the cells of the stigma, by the viscid secretion of which it is nourished. In most plants, but one pollen-tube is emitted by each pollen-cell, but the number varies, and according to some observers, is sometimes twenty or more. The pollen-tube continues to elongate by growth at its apex, and passes down through the conducting tissue of the canal of the style (*fig.* 562, *tp*) when this exists, or directly into the ovary when it is absent. This growth of the tube was formerly supposed to be due to endosmotic action occurring between the contents of the pollen and the secretion of the stigma and style, but it is now known to be a true growth—a kind of germination, which is occasioned by the nourishing viscid secretion which it meets with in its passage through the stigma and style.

These tubes are extremely thin. They vary in length according to circumstances, but are frequently many inches. The time required for their development also varies in different pollens; thus, sometimes the pollen-tubes are developed almost immediately the pollen comes into contact with the stigma, whilst in other cases, many hours are required for the purpose. The pollen-tubes also occupy a varying time in traversing the canal of the style,—that is, from a few hours to some weeks. When the pollen-tubes have penetrated the stigmatic tissue, the secretion of the latter ceases and the stigma withers. The upper part of the pollen-tubes also wither above, as growth takes place below.

The pollen-tubes having reached the ovary are distributed to

the placenta or placentas, and then come into contact with the ovules. One or sometimes two of these pollen-tubes enter into the micropyle of each of the ovules (*figs.* 1115 and 1116), by which it reaches the nucleus and embryo-sac. When it reaches the

Fig. 1115.

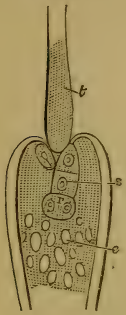


Fig. 1116.

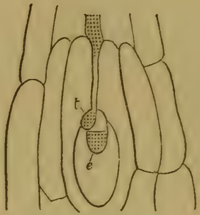


Fig. 1115. Section of the ovule of a species of *Œnothera*. *t.* Enlarged end of pollen-tube containing fovilla, which has entered the micropyle, and is seen pressing inwards the apex of the embryo-sac. *sr.* Impregnated germinal vesicle, which already begins to exhibit two parts ; one, the upper, forming a suspensor, *s*, and another, below, *r*, a globular body, which ultimately becomes the embryo. *c.* Endosperm cells or albumen.——*Fig.* 1116. Section of the ovule of a species of *Orchis*. *t.* Enlarged end of the pollen-tube which has passed through the micropyle, and is closely applied to the embryo-sac, the upper side of which it has pushed inwards. *e.* Germinal vesicle in the interior of the embryo-sac in an impregnated state, and dividing into two portions, the lower of which is the rudimentary embryo, and the upper forms a suspensor.

latter it is generally somewhat enlarged (*figs.* 1115, *t*, and 1116, *t*), and adheres firmly to it at or near its apex (*figs.* 1115 and 1116). The embryo-sac is frequently introverted to a slight extent at the point of contact with the pollen-tube (*figs.* 1115 and 1116), and it is stated by Hofmeister, to perforate it in *Canna*, but if such a perforation occurs in this case, it is altogether an exception to what is generally observed. As soon as contact of the pollen-tube and embryo-sac is effected, a kind of *conjugation*, or endosmotic action between the contents of the two, takes place, the result of which is the development of one, or rarely two, as in *Orchis* and *Citrus*, or more, of the germinal vesicles, into embryos. According to Henfrey, as previously noticed (see p. 759), the first change is the development of the germinal corpuscle into a germinal vesicle or cell.

The germinal vesicle in its development into an embryo, generally divides in a transverse manner into two cells (*fig.* 1116, *e*); the upper of which by elongating, and frequently by further

division, forms a *suspensor* (*fig.* 1115, *s*), by which the lower cell is suspended from the apex of the embryo-sac. This lower cell assumes commonly a globular form (*figs.* 1115, *r*), and ultimately by cell-division forms the embryo, which is either mono- or di-cotyledonous according to the conditions under which it is developed. The suspensor is not present in all cases, while in others in which it is found it varies in its length. It is evidently not essential in all instances, as it always shrivels up during the development of the cell which it supports into the embryo. The latter, therefore, is the true rudimentary embryo. Other variations occur in the mode in which the germinal vesicle is developed into an embryo, but the above is a general sketch of the subject, and all that our space will allow us to notice.

The changes which take place in the ovule during the development of the embryo, and the subsequent growth of the latter, have been already alluded to when treating of the seed. (See *Nucleus or Kernel*, p. 342; and, *Development of the Embryo*, p. 345.)

Hybridization, Hybridation, or the Production of Hybrids in Plants. — If the pollen of one species is applied to the stigma of another species of the same genus, should impregnation take place, the seeds thus produced will give rise to offspring intermediate in their characters between the two parents. Such plants are called *hybrids* or *mules*. The true hybrids which are thus produced between two species of the same genus, must not be confounded with simple *cross-breeds*, which result from the crossing of two varieties of the same species; these may be termed *sub-hybrids*.

As a general rule, true hybrids can only be produced between nearly allied species, although a few exceptions occur, where hybrids have been formed between allied genera; these are called *bigeners*. The latter, however, are not so permanent as the former, for in almost all cases they are short-lived.

Hybrids are always intermediate in their characters between the two parents, but they generally bear more resemblance to one than the other. Sometimes the influence of the male parent is most evident, and at other times that of the female, but no law can at present be laid down with regard to the kinds of influence exerted by the two parents respectively, in determining the characters of the hybrid. In very rare cases, it has been noticed, that different shoots of the same hybrid plant have exhibited different characters, some bearing flowers and leaves like their male parent, others like the female, and some intermediate between the two. In such cases, therefore, the hybrid characters are more or less separated in the different shoots, which present respectively, the characters of one or the other of their parents.

Hybrids rarely produce fertile seeds for many generations, and hence, cannot be generally perpetuated with any certainty by them; if they should be of a woody nature, however, they may be readily propagated by budding, grafting, &c. Hybrids may be rendered fertile by the application of the pollen of one of their parents; the offspring in such a case resembles closely the parent from which the pollen was obtained. By the successive impregnation of hybrids through three, four, or more generations with the pollen of either of their parents, they revert to their original male or female type; thus, when the hybrid is successively impregnated by the pollen of its male parent, it reverts to the male type; and when with that of the female, to the female type. The influence of the latter is, however, more gradual.

Hybrids rarely occur in wild plants. This arises chiefly from the following causes; thus, in the first place, the stigma is more likely to be impregnated with the pollen from the anthers immediately surrounding it, than by that of others remote from it; and secondly, the stigma has a sort of *elective affinity* or *natural preference* for the pollen of its own plant, so much so, indeed, that Gaertner found, that if the natural pollen and that of another species be applied to the same stigma at the same time, the latter remained inert, and the former alone fecundated the ovules; and, moreover, that when the natural was applied a short period subsequently to the foreign pollen, the seeds thus produced never formed hybrids. Hybrids appear to be produced more frequently in wild plants when the sexes are in separate flowers, and more especially when such flowers are on different plants. Recent investigations show that hybrids are far more common amongst wild plants than the above observations indicate.

Hybrids are, however, frequently produced artificially by gardeners applying the pollen of one species to the stigma of another, and in this way, important and favourable changes are effected in the characters of our flowers, fruits, and vegetables. Such are not, however, commonly true hybrids, but simple cross-breeds.

Recent investigations would appear to show, that a similar law as regards hybridation occurs in the Cryptogamia as in the Phanerogamia. Thus, Thuret has succeeded in fertilizing the spores of *Fucus vesiculosus* with the spermatozoids of *Fucus serratus*, an allied species; but he failed in his attempts to fertilize the spores of one genus of the Melanosporeous Algæ by the spermatozoids of another. No other direct evidence has at present been adduced as to the hybridization of Cryptogamous plants, but there can be but little doubt, that hybrid Ferns are sometimes produced when a number of species are cultivated together, for it has been noticed, that under such

circumstances, plants make their appearance, which present characters of an intermediate nature between two known species.

3. Of the Fruit.—When the process of fertilization has been effected in the ovule, as already noticed (see p. 297), important changes take place in the walls of the ovary and the surrounding organs of the flower, the result of which is the formation of the fruit. The calyx and corolla generally fall off, or if persistent, do not form any portion of the fruit, except when the calyx is adherent, as in the Apple (*fig.* 702), when it necessarily constitutes a part of the pericarp; the style and stigma also become dry, and either fall off, or are persistent, as in the Poppy (*fig.* 428), and Anemone (*fig.* 684). The principal changes, however, take place in the wall of the ovary, which usually becomes more or less swollen, and soon undergoes important chemical changes, and forms the pericarp, either by itself, or combined with the adherent calyx. Some pericarps, as already noticed (p. 300), are fully developed without the fertilization of the ovule, as those of many Oranges, Grapes, Bananas, &c. The fruits thus formed, although frequently more valuable than others for food, &c., are useless for reproduction.

The fruit in its growth attracts the food necessary for that purpose from the surrounding parts, hence, the fruiting of plants requires for its successful accomplishment an accumulation of nutrient matter, and is necessarily an exhaustive process. That the reproductive processes, and especially the maturation of the pericarp, tends to exhaust the individual, is proved in various ways. Thus, plants are annual, as already noticed (p. 126), when they fruit the same year in which they are developed from the exhaustion of nutrient matter thus occasioned; and that such is the reason is proved by the fact, that we can make annuals, biennial or even perennial, by plucking off the flower-buds as they are developed, and thus enabling them to produce wood, &c. Again, a bad fruit year is generally succeeded by a good one, and *vice versa*, because in the former case an additional supply of nutrient matter is stored up for the fruiting season, and in the latter there is a diminished amount. Again, if a branch of an unproductive tree have a ring of bark removed so as to prevent the downward flow of the elaborated sap, its accumulation above will cause the branch to bear much fruit. Pruning depends for its success upon similar principles. In order to obtain good fruit it is also necessary, not to allow too many to come to perfection on the same plant. Other matters connected with this exhaustion by fruiting have been already alluded to, in speaking of Annual, Biennial, and Perennial Roots, at page 126.

The changes produced upon the atmosphere in the maturation or ripening of the fruit, depend upon the nature of the pericarp. Thus, when the pericarp preserves its green state, and always

when first formed, it produces similar changes to the leaves; but when of other colours than green, and more especially when succulent, it evolves carbonic acid gas at all times, instead of oxygen gas, as in the former cases, under the influence of solar light.

The chemical constitution of fruits varies according to their nature and age. When the pericarp is of a dry nature, it commonly assumes a whitish or brownish colour, and its cells become incrusted with hardened matters (*lignine*). Under such circumstances, no further changes take place in its chemical constitution, and its vital activity ceases. When the pericarp, however, becomes of a succulent nature whilst ripening, it assumes various tints; transpiration goes on from its outer cells, the contents of which thus becoming of a denser nature, absorb the watery matters from those within them, and these in like manner react upon the contents of those within them, so that there is a constant passage of fluid matters from the surrounding parts by endosmotic action into the pericarp; in this way, therefore, it continues to enlarge, until it has arrived at maturity, when transpiration nearly ceases from the deposition of waxy matter in or upon the epidermal cells, and the stalk by which it is supported to the plant becomes dried up.

The chemical constitution of succulent pericarps varies according to their age. When first formed they have a like composition with leaves, and have but little or no taste. After a time they acquire an acid flavour from the formation of vegetable acids, and salts with an acid reaction. The nature of these acids and salts varies in different fruits; thus the Grape contains tartaric acid chiefly and bitartrate of potash, the Apple, malic acid, and the Lemon, citric acid. As the pericarp ripens, saccharine matter is formed, and the quantity of free acids diminishes, partly from their conversion into other matters, and partly from their combination with alkalies. In order that these changes may be properly effected, it is necessary that the fruit be exposed to the sun and air, for if grown in the dark, it will continue acid; and will be moreover, much less sweet when developed in diffused daylight, than when freely exposed to the sun. As fruits ripen they evolve carbonic acid gas, as already noticed, give off watery fluids, and a sensible elevation of temperature may be noted.

The origin of the sugar of fruits, and even its nature, is not satisfactorily determined. According to most observers, ripe fruits contain grape sugar, but M. Buignet has lately stated, that the sugar which is primarily formed in acid fruits is cane sugar ($C_{12}\ H_{11}\ O_{11}$), and that during the process of ripening, this sugar is gradually changed into interverted sugar ($C_{12}\ H_{12}\ O_{12}$), but very often there remains in the ripe fruit a mixture of these two sugars. The origin of the sugar is variously attributed

to the transformation of the acids, cellulose, lignine, starch, dextrin, gum, and matters of a like nature. According to M. Buignet's recent investigations, the cause of the change of the primarily formed cane sugar into interverted sugar is not the acids of the fruits, but that it appears to depend on the influence of a nitrogenous body playing the part of a glucosic ferment, analogous to that which M. Berthelot has extracted from yeast. M. Buignet adds, that "the abundance in which starch is found distributed through the vegetable kingdom, leads to the supposition that it is the true source of the saccharine matter in fruits. Its presence cannot, however, be detected in green fruits, either by the microscope or by iodine, excepting in green bananas, which contain a notable quantity of starch." M. Buignet also notices that green fruits contain a particular principle resembling the tannins, which is capable of being converted into a sugar identical with the sugar from starch, under the influence of dilute acids and a proper temperature. The proportion of this tannin diminishes in fruits in the same ratio that the proportion of sugar increases.

The changes which take place in the composition of fruits during ripening are well exhibited in the following table founded upon Bérard's observations:—

Names of Fruits.	Water.		Sugar.		Ligneous Matter.	
	Unripe.	Ripe.	Unripe.	Ripe.	Unripe.	Ripe.
Apricots . . .	89·39	74·87	A trace when young, and then 6·64	16·48	3·61	1·86
Red Currants . .	86·41	81·10	0·52	6·24	With the seeds:— 8·45.	8·01
Duke Cherries .	88·28	74·85	1·12	18·12	2·44	1·12
Greengage Plums .	74·87	71·10	17·71	24·81	1·26	1·11
Melting Peaches .	90·31	80·24	0·63	11·61	3·01	1·21
Jargonelle Pears .	86·28	83·88	6·45	11·52	3·80	2·19

The pericarp of some fruits has developed in it during the process of ripening fixed and essential oils, as well as other substances of an aromatic nature. According to Frémy, the inner walls of the cells of succulent fruits in an unripe state, consist of a substance called *pectose*, which is insoluble in water. This is converted in ripe fruits into *pectine*, which is soluble in water. Pectine is afterwards transformed into *pectic acid*. Frémy has also noticed, that at the period of maturation the thickness of the cell-walls diminishes rapidly; hence, it would appear that these transformations of the pectic compounds play an important

part in the changes which are taking place during the ripening of the fruit. M. Frémy has recently discovered a new acid in fruits, to which he has given the name of *cellulic acid;* but at present nothing is known of its action or use in the plant.

The time in which a fruit is considered ripe varies in different cases. When the pericarp is of a dry nature, the fruit is looked upon as ripe just before it opens ; but when the pericarp is of a pulpy nature and edible, we commonly regard it as mature when most agreeable as food. Hence the Apple is considered to be ripe in a state in which the Medlar would be regarded as unripe and unfit for food.

When succulent fruits are ripe, they undergo another change, a species of oxidation, which produces either a decay, or *bletting* of their tissues, as it has been called by Lindley. This bletting, according to Berard, is especially evident in the fruits of the Pomaceæ and Ebenaceæ, and it would appear that the more austere the fruit is, the more it is capable of bletting regularly. This bletting appears to be peculiar to such fruits, and may be regarded as a state intermediate between maturity and decay. A Jargonelle Pear in passing from ripeness to bletting, according to Berard, loses a great deal of water (83·88, which it contains when ripe, being reduced to 62·73); pretty much sugar (11·52, being reduced to 8·77); and a little lignine (2·19, reduced to 1·85) ; but it acquires, at the same time, rather more malic acid, gum, and animal matter.

The time required by different plants for ripening their fruits varies much, but almost all fruits come to maturity in a few months. Some, as those of Grasses generally, in a few days commonly; while others, as some of the Coniferæ, &c., require more than twelve months.

4. Of the Seed. — The structure and general characters of the seed, as well as the origin and progressive development of its parts, have been already fully alluded to in the section of this work which is especially devoted to the Seed (p. 335—351).

Our limited space prevents us from alluding to the multitude of ways and contrivances by which the natural dissemination of seeds is effected; and to the number of seeds produced by plants. Suffice it to say, that in all cases, a great many more seeds are matured than are required for the propagation of the species; and thus, on the one hand, while the extinction of the species in consequence of the decay of seeds, and their use for food, &c., by animals, is provided against, at the same time, their too great increase is prevented.

Vitality of Seeds.—Seeds vary very much as to the time which they retain their vitality. By retaining vitality we mean preserving their power of germinating. This vitality is frequently lost long before they lose their value for food. Some seeds as those of an oily or mucilaginous nature, or which contain much

tannin, speedily lose their vitality, and decay; this is the case, for instance, with Nuts and Acorns, and hence, when seeds of this nature are required for propagation, they must be sown immediately or within a short time of their arriving at maturity, or special means must be adopted for their preservation. Other seeds, such as those of a farinaceous nature, as Wheat and Cereal grains generally, or those with hard and bony integuments, as many of the Leguminosæ, frequently retain their vitality for some years, and even in certain cases for many centuries.

From the experiments of De Candolle, those of a Committee of the British Association, and others, it would appear generally, that the seeds of the Leguminosæ and Malvaceæ preserve their vitality longest, while those of Compositæ, Cruciferæ, Graminaceæ soon lost their germinating power. Some exceptions, however, to the above statement occur in these orders.

Under particular circumstances, it seems certain, that seeds may, and have preserved their vitality for centuries. Some of the cases brought forward as illustrations of this capability of seeds are, however, not supported by careful observations, as for instance, that of the vitality of Wheat taken from Egyptian mummies. There are no well-authenticated instances of wheat taken from mummies which has been untampered with, germinating. Some instances of seeds germinating after having been preserved for centuries are, however, supported by good evidence. Thus Lindley records the remarkable case of some Raspberry plants having been "raised in the garden of the Horticultural Society from seeds taken from the stomach of a man, whose skeleton was found thirty feet below the surface of the earth, at the bottom of a barrow which was opened near Dorchester. He had been buried with some coins of the Emperor Hadrian, and *it is therefore probable that the seeds were sixteen or seventeen hundred years old.*" Mr. Kemp in the Annals of Natural History, has narrated a still more remarkable case, in which the retention of the vitality of seeds for many centuries was undoubted. This gentleman received some seeds which were found upwards of twenty-five feet below the surface of the earth at the bottom of a sand-pit in process of excavation. Specimens of these, upon being sown, produced plants of *Polygonum Convolvulus*, *Rumex Acetosella*, and a variety of *Atriplex patula*. All these seeds were of a mealy or farinaceous nature. Mr. Kemp concluded from various circumstances, that these seeds were deposited at a period when the valley of the Tweed was occupied by a lake; and as it is certain that in the time of the Romans, about 2000 years ago, no lake existed there, they must have retained their vitality during many centuries. Many other cases might be cited of a similar character to the above, but these must suffice, as our space is limited. It has been noticed that when a new soil is turned up, it is commonly found that

plants previously unknown in the locality spring up, hence the seeds of such must have lain dormant for frequently a very lengthened period.

Preservation and Transportation of Seeds.— As many persons frequently wish to send seeds to a distance, a few words on the best means of preserving them for that purpose will doubtless be acceptable to our readers. When seeds are enclosed in hard or dry pericarps, they should be preserved and transported in them. This is the case with those of many Leguminous and Coniferous plants. When the pericarps are soft or liable to decay, the seeds should be removed from them. In all cases, seeds when required for preservation should be gathered when quite ripe, as at that period their proximate principles are in a more stable condition than when unripe, when they are very liable to change. Seeds should be also preserved quite dry. Seeds of a farinaceous nature, if ripe and dry, will retain their vitality for a long period, and such may be readily transported to a distance. For the latter purpose they should be placed in perfectly dry papers in a dry coarse bag, which should be afterwards suspended from a nail in a cabin, in which position they are maintained at a moderate temperature and exposed to free ventilation. Such seeds require no further care. But seeds of an oily or mucilaginous nature, or which contain much astringent matter, require, as a further protection, to be excluded from the air. For this purpose they are best packed in stout boxes lined with tin, and filled with dry sand or charcoal powder. The sand or charcoal powder and the seeds should be placed alternately in layers, and the whole firmly pressed together. Such seeds, however, even when thus protected, frequently lose their vitality. A coating of wax has in some cases been found to preserve effectually the vitality of seeds. Probably seeds which are difficult of preservation, might be transported in bottles containing carbonic acid, and hermetically sealed. Wardian cases are also an important means for transporting seeds (see p. 743), and should be resorted to, when possible, in all doubtful cases.

Germination.—By germination we mean the power or act by which the latent vitality of the embryo is brought into activity, and it thus becomes an independent plant capable of supporting itself. The germination of Acotyledonous plants has already been sufficiently alluded to, when treating of the Root, at page 127, and in the sections devoted to the Organs of Reproduction, and the Sexual Reproduction of Acotyledonous Plants. Our future remarks will apply therefore solely to Cotyledonous plants.

Length of Time required for Germination.—The time required for germination varies much according to the nature of the seeds and the conditions under which they are placed. Generally speaking seeds germinate most rapidly directly after they

are gathered. If preserved till they are quite dry, in some cases the process of germination is months in being effected. The seeds of the garden cresses will frequently germinate in twenty-four hours, but the majority of seeds do not germinate for from six to twenty days, and some require months or even years. Germination is generally prolonged when the embryo is invested by hardened integuments or albumen ; and it is usually of a limited duration in exalbuminous seeds, more especially if such seeds have thin soft integuments. Heat is the agent which most accelerates germination.

Conditions requisite for Germination.—A certain amount of heat and moisture, and a free communication with atmospheric air, are in all cases necessary to the process of germination. Electricity is also considered by some observers to promote it, but its influence in the process is by no means proved, and if exerted it is apparently of but little importance. Absence from light, however, is another condition, which is favourable to germination in most cases.

Moisture is required to soften the parts of the seed and to take up all soluble matters ; the cells of which seeds are composed are in this way enabled to expand, and the embryo to burst through the integuments.

Heat is necessary to excite the dormant vitality of the embryo, but the amount required varies very much in different seeds. As a general rule from 50° to 80° of Fahr. may be regarded as most favourable to germination in temperate climates, but some seeds will germinate at a temperature of 35° Fahr. ; and those of many tropical plants require a temperature of from 90° to 120° Fahr., or sometimes much higher, for germination.

Air, or at least oxygen gas, is required to combine with the superfluous carbon of the seed, which is thus evolved with a sensible increase of temperature, as is well seen in the malting of Barley, as carbonic acid. The necessity of a proper supply of oxygen is proved by the fact, that seeds will not germinate when buried too deeply in the soil, or when the soil is impervious to air. This explains why seeds frequently lie dormant at great depths in the soil, and only germinate when that soil is brought to the surface ; and hence we see the necessity of admitting air to seeds by the ordinary operations of agriculture.

Process of Germination.—When the above requisites are supplied in proper proportions to suit the requirements of different seeds, germination takes place, but should either be wanting or in too great amount, the process is more or less impeded, or altogether arrested. The most favourable seasons for germination are spring and summer ; and seeds sprout most readily in loose pulverised and properly drained soil, at a moderate depth,

as under such circumstances, while the light is excluded, air, moisture, and warmth, have free access. Seeds thus placed absorb moisture, soften, and swell; certain chemical changes go on at the same time in the substance of the albumen, or, when that is absent, in the cells of the cotyledonary portion, by which a proper supply of nourishment is provided for the embryo. These chemical changes chiefly consist in the conversion of starch and other analogous substances which are insoluble and therefore not in a suitable state for absorption, into soluble matters such as dextrine and grape sugar. The immediate cause of this transformation of starch is due to a nitrogenous substance called Diastase, which is developed during germination, from an alteration of a portion of the azotized contents of the seed. During these changes, as already noticed, heat is evolved, and carbonic acid gas driven off from the combination of the superfluous carbon of the seed with the oxygen of the air. The nutriment being thus available for use, it is absorbed dissolved in water by the embryo, which is thus nourished, increases in size, and ultimately bursts through the integuments of the seed. Its lower extremity or radicle (*fig.* 160, *r*), or one or more branches from it (*fig.* 742, *r*), is commonly protruded first from its proximity to the micropyle, which is the weakest point in the integuments; and by taking a direction downwards becomes fixed in the soil. The opposite extremity soon elongates upwards (*fig.* 161, *t*), and is terminated above by the plumule or gemmule, which is the first terminal bud or growing apex of the stem; and at the same time the cotyledonary portion is either left under ground or is carried upward to the surface. The embryo during this development continues to be nourished from the matters contained in the albumen or cotyledonary portion, and ultimately by continuing to absorb nutriment it is enabled to develop its first leaves (*primordial*) (*fig.* 161, *d*), and root (*fig.* 161, *r*), and then the young plant being placed in a position to acquire the necessary nourishment by itself for its further support and growth from the media by which it is surrounded, is rendered independent of the seed, the cotyledonary portion accordingly perishes, and the act of germination is complete.

Direction of Plumule and Radicle.—The cause which leads to the development of the axis of the embryo in two opposite directions has not yet been satisfactorily demonstrated, although much has been written on the subject. By some it has been referred to the action of darkness and moisture on the root, and that of light and dryness on the stem. By others it has been attributed to gravitation and the state of the tissues; others again, regard endosmotic action as the cause. All these explanations are unsatisfactory, and need not be further alluded to in an elementary manual. It seems certain, however, that the chief

cause of the downward descent of the root is due to the greater amount of moisture which it receives in that direction, and such a supply is necessary for the multiplication of its cells near the extremity.

Differences between the Germination of Dicotyledonous and Monocotyledonous Seeds.—There are certain differences between the germination of Monocotyledonous and Dicotyledonous embryos, which have already been alluded to briefly (see pp. 126 and 127), but which require some further notice.

1. *Monocotyledonous Germination.*—The seeds of Monocotyledonous plants, in by far the majority of instances, contain albumen, which, as the embryo developes, is either entirely absorbed, or a more or less considerable portion remains, as in the seed of the Phytelephas or Ivory Palm, where the contents of the constituent cells are removed, and the walls left as a kind of skeleton.

The single cotyledon of Monocotyledonous seeds, when they contain albumen, always remain entirely (*fig.* 742, *c*), or partially within the integuments, during germination. The intra-seminal portion of the cotyledon corresponds to the limb of the cotyledonary leaf, and the portion which elongates beyond the integuments (extra-seminal) represents the petiolar portion. The latter part varies much in length, and is commonly terminated by a sheath, which encloses the young axis with the plumule. At other times, there is no evident petiolar part, but the sheathing portion enveloping the axis remains sessile on the outside of the seed, and elongates in a tangential direction to it.

In the Oat (*fig.* 742), the cotyledon, *c*, is seen within the seed, and the plumule, *g*, rises upwards from its axil, into the air.

In some few Monocotyledonous Orders, such as Naiadaceæ, Alismaceæ, &c., where the seeds are exalbuminous, the cotyledon is commonly freed from the integuments, and raised upwards with the plumule.

As already noticed (p. 127), in the germination of Monocotyledonous embryos, the radicle is not itself continued downwards so as to form the root, but it gives off one or more branches of nearly equal size, which separately pierce its extremity, and become the rootlets (*fig.* 742, *r*). Each of these rootlets, at the point where it pierces the radicular extremity, is surrounded by a cellular sheath termed the *coleorhiza* (*fig.* 742, *co*). This mode of germination is commonly termed *endorhizal.*

Dicotyledonous Germination.—The seeds of Dicotyledonous plants are either albuminous or exalbuminous, and their germination in such respects, as a general rule, presents no peculiarity worth notice. The two cotyledons either remain within the integuments of the seed as fleshy lobes, as in the Horse-chestnut,

Oak, Bean, Pea (*fig.* 160, *c*, *c*), in which case they are said to be *hypogeal* (from two Greek words signifying under the earth); or, as is more commonly the case, they burst through the coats, and rise out of the ground in the form of green leaves (*fig.* 161, *c*, *c*), in which case they are *epigeal* (from two Greek words signifying upon or above the earth). In the course of development, the cotyledons commonly separate, and the plumule comes out from between them (*figs.* 160, *n*, and 161). In those cases where they remain within the integuments, they sometimes become more or less united, so that the embryo resembles that of a Monocotyledon; but a Dicotyledonous embryo may be always distinguished from a Monocotyledonous one, by its plumule coming out from between the bases of the cotyledons, and not by passing through a sheath, as in Monocotyledons (*fig.* 162).

The radicle of a Monocotyledonous embryo (see p. 126) is itself prolonged downwards by cell-multiplication just within its apex (*fig.* 230, *a*), to form the root. An embryo which germinates in this way, is termed *exorhizal.*

As a general rule, seeds do not germinate until they are separated from their parents, but in some cases, and more especially when invested by pulp, as in the Gourds, Melon, Cucumber, Papaw, &c., they do so before they are detached. In the above plants such a mode of germination is altogether exceptional, but in the plants of the natural order Rhizophoraceæ, as the Mangrove (*fig.* 235), the seeds commonly germinate in the pericarp before being separated from the tree, in which case the radicle is protruded through the integuments of the seed and pericarp, and becomes suspended in the air, where it elongates.

CHAPTER 2.

GENERAL PHYSIOLOGY, OR LIFE OF THE WHOLE PLANT.

Having now examined the special or individual functions of the different organs of the plant, we proceed to give a general sketch of the whole plant in a state of life or action. In doing so, we shall first notice the substances required as food by plants; then proceed to consider the function of *absorption* by which food is taken up, dissolved in water, by the roots; then the process of *circulation*, or more properly the distribution of the fluid food thus absorbed; next in order will be described the functions of *respiration* and *assimilation*, the objects of which are to aerate and elaborate the crude food or sap, which, when it reaches the leaves and other external organs, is not adapted for

the requirements of the plant, but is but little altered from the condition in which it was absorbed; and lastly, our attention will be briefly directed to the functions of *development* and *secretion.*

Section 1. Food of Plants, and its Sources.

The various substances required as food can only be ascertained when we know the elementary composition of the parts and products of plants; for as plants have no power of forming these elements for themselves, they must have derived them from external sources, and hence an acquaintance with them is at once an indication to us of the nature of their food.

As plants are commonly fixed to the soil, they must gain their food from it, or from the air which surrounds them. In by far the majority of cases, plants take up their food, both from the air by their leaves in a gaseous or vaporous state, and from the earth dissolved in water. No plants have the power of taking up nutriment except in the state of gas or vapour, or in a fluid state. Those plants which are termed Epiphytes or Air Plants, as Orchids (*fig.* 237), derive their food entirely from the air by which they are surrounded (see p. 124); while Parasites (*figs.* 238 and 239) are essentially different from both Epiphytic and ordinary plants, since their food, instead of being derived entirely from inorganic materials, which are afterwards assimilated in their tissues, as is the case with them, is obtained entirely or partially from the plants upon which they grow,—that is, in an already assimilated condition. (See p. 125.)

The materials of which plants are composed, and which, as stated above, are either derived from the air or the earth, or more commonly from both, and which consequently constitute their food, are of two kinds, called respectively the *organic* and the *inorganic.* The process of burning at once enables us to distinguish the comparative proportion of these, and acquaints us with one of their distinctive peculiarities. Thus, if we take a piece of wood, or a leaf, or any other part of a plant, and burn it as perfectly as we are able, we find that the greater portion disappears in the form of gas and vapour, but a small portion of the original substance remains in the form of ash or incombustible material. The former are termed the *organic,* and the latter the *inorganic* or *earthy constituents.* The term organic is applied because such materials especially constitute the real fabric of the plant, and are more essentially concerned in the formation of its organic products and secretions. The relative proportion of the organic and inorganic constituents varies in different plants, but as a general rule, the former constitute from 89 to 99 parts, while the latter form from one to about eleven parts in every hundred, of all plants.

1. *The Organic Constituents and their Sources.*—The organic constituents of plants are, Carbon, Oxygen, Hydrogen, and Nitrogen. The first three alone form the cellulose of which the cell-walls are composed (see p. 9), and are therefore to be considered as constituting by themselves the proper fabric of the plant; while the protoplasmic contents of the cell are formed of compounds of these three elements, with the fourth organic constituent—nitrogen. It would appear also, that two other elements, namely, Sulphur and Phosphorus, are also necessary constituents of these nitrogenous cell-contents.

These organic constituents are required alike by every species of plant, hence the great bulk of all plants is composed of the same elements, although the proportion of these varies to some extent in the different species, and even in different parts of the same plant. The following table, by Johnston, indicates the relative proportion of the organic and inorganic constituents of some of our vegetable food substances in 1000 parts, and of the different elements of which the former are composed. These substances were first dried at a temperature of 230° Fahr:—

	Wheat.	Oats.	Peas.	Hay.	Turnips.	Potatoes.
Carbon . .	455	507	465	458	429	441
Hydrogen .	57	64	61	50	56	58
Oxygen . .	430	367	401	387	422	439
Nitrogen .	35	22	42	15	17	12
Ash . .	23	40	31	90	76	50

We must now make a few remarks on each of the organic constituents, the sources from which they are derived, and the state in which they are taken up by plants.

Carbon is the element which forms the largest proportion of all plants; its amount varies in different species from 40 to 60 per cent. That plants thus contain a large proportion of carbon may be conveniently proved by taking a piece of wood, the weight of which has been ascertained, and converting it into charcoal, which is impure carbon containing in its substance also a small quantity of the inorganic constituents or ashes. The charcoal thus produced is of the same shape as the piece of wood from which it was obtained, and when weighed it will be found to have constituted a large proportion of its original substance. As carbon is a solid substance and insoluble in water, it cannot be taken up in its simple state, as plants, as already noticed (see pp. 731 and 774) can only take up their food as gas or vapour, or dissolved in water. In the state of combination however, with oxygen, it forms carbonic acid, which is always present in the atmosphere and the soil. Carbonic acid is also soluble to some extent in water. Hence we have no difficulty in ascertaining the source of carbon and the condition and modes in which it is absorbed by the plant; thus it is taken up combined with oxygen in the form of carbonic acid, from the air

directly in a gaseous state by the leaves, and from the earth, dissolved in water, by the roots.

Oxygen is, next to carbon, the most abundant organic constituent of plants; and when we consider to what an enormous extent it exists in nature, constituting as it does about 21 per cent by volume of the atmosphere we breathe, eight ninths by weight of the water we drink, and at least one half of the solid materials around us and of the bodies of all living animals; we see that there are abundant materials from which plants can obtain this necessary portion of their food. The whole of the oxygen required by plants as food appears to be taken up by them, either combined with hydrogen in the form of water, or with carbon as carbonic acid. Some of the oxygen is therefore obtained by the roots from the soil, and the other portion from the air by the leaves.

Hydrogen, the third organic constituent of plants, as just noticed, forms one ninth by weight of water, and it is in this form that plants obtain nearly the whole of this ingredient of their food. It does not exist in a free state in the atmosphere nor in the soil, and hence cannot be obtained by plants in a simple state. In combination, however, with nitrogen, it forms ammonia, which always exists to some extent in the atmosphere and in the excretions of animals; and is also always produced during the decomposition of animal matter. Ammonia exists in a gaseous state in the atmosphere, and being freely soluble in water, the rain as it passes through the air dissolves it, and carries it down to the roots, by which organs it is taken up. The roots in like manner absorb the ammonia which is contained in the soil. While the larger proportion of hydrogen, therefore, is taken by plants combined with oxygen as water, a small portion is derived with nitrogen in the form of ammonia.

Nitrogen, the fourth and last organic constituent of plants, constitutes about 79 per cent of the volume of the atmosphere, and is an important ingredient in animal tissues. It also exists in combination with oxygen as nitric acid in rain water, and in the soil as a constituent of the various nitrates there found. Whether nitrogen can be taken up by plants in a free state is at present doubtful (see p. 737), but it is quite clear that the principal form in which it is absorbed is as ammonia. Some believe that a small part is obtained from nitric acid and nitrates.

Both *sulphur* and *phosphorus*, which as we have noticed (p. 775) are always combined with nitrogen in the protoplasmic cell-contents, are obtained in a state of combination from the soil. They are dissolved in the water, and are thus absorbed by the roots.

In reviewing the sources of, and modes in which, the different organic constituents of plants are derived and taken up, we see

that the sources are the earth and the air, more particularly the latter; and that they are principally absorbed in the forms of carbonic acid and water, the latter of which is not only food in itself, as it is composed of oxygen and hydrogen, two of the essential organic constituents of plants, but it is also the vehicle by which other food is conveyed to them.

2. *The Inorganic Constituents and their Sources.* — The amount of inorganic matter found in plants, as already observed (p. 774), is very much less than that of the organic. The inorganic matters are all derived from the earth in a state of solution in water, and hence we see again, how important a proper supply of water is to plants. While the organic constituents are the same for all plants, the inorganic constituents vary very much in different plants. The inorganic constituents differ from the organic also, in the following particulars: — 1st, they are incombustible, and hence remain as ash, when the organic constituents are dissipated by burning; 2nd, they are not liable to putrefaction, as is the case with them, under the influence of warmth and moisture; and 3rd, they can be formed in the laboratory of the chemist, whereas the organic, as a rule, have at present, only been produced in the tissues of the living plant.

The inorganic constituents of plants are the following: — Chlorine, Bromine, Iodine, Fluorine, Sulphur, Phosphorus, Silicon, Potassium, Sodium, Calcium, Magnesium, Aluminium, Manganesium, Iron, Zinc, and Copper. Some of these appear to be almost universally distributed in varying proportions, but others are only occasionally met with. These various inorganic constituents are not taken up in their simple states, but principally as soluble oxides, chlorides, bromides, fluorides, sulphates, phosphates, silicates, &c.

Although the amount of inorganic matter in plants is very much smaller than that of organic, still this portion, however small, is necessary to the life and vigorous development of most plants, and probably of all; although, in certain Moulds, no inorganic constituents have been detected.

The inorganic constituents of plants are of great importance in an agricultural point of view, as it is to their presence or absence, the quantities contained, and the solubility or insolubility of their compounds, which are present in a particular soil, that it owes its fertility or otherwise, and its adaptability of growing with success one or another kind of plant.

Rotation of Crops.—The principle of the rotation of crops in agriculture is founded upon the fact of different plants requiring different inorganic compounds for their growth; and hence, a particular soil which is rich in materials necessary for some plants, may be wanting or deficient in those required by others. (See also *Excretions of Roots*, p. 732.) Thus, Wheat or any

Cereal Crop, requires more especially for its proper growth a full supply of silica and phosphates; hence it will only flourish in a soil containing the necessary amount of such substances. As growth proceeds, these constituents are absorbed in a state of solution by the roots, and are applied to the requirements of the plants. When the grain is ripe, it is removed as well as the straw, and hence the silica and phosphates obtained from the soil will have been also removed with them: the result of this is necessarily, except in fertile virgin soil, that these ingredients will not be then contained in the soil in sufficient quantities for the immediate vigorous growth of the same class of plants; but by growing in a soil thus exhausted by Wheat another crop of a different class of plants, such as Clover, Peas, Beans, &c. &c., which require either altogether different substances, or a different amount or distinct combinations of the same substances, we may obtain a profitable crop, while at the same time certain chemical changes will go on in the soil, and other ingredients will be taken up from the atmosphere, &c., by which the land will be again adapted for the growth of Wheat, &c.

The consideration of the above facts shows how important it is for the agriculturist to have some acquaintance with vegetable physiology and chemistry. He should know the composition of the various soils, and the plants which he cultivates, as well as the nature of the compounds required by them, and the modes in which they are taken up, and hence he would be able to adapt the particular plants to the soils proper for them, and if such soils did not contain the substances necessary for their life and vigour, he must supply them in the form of manures. The applications of chemistry and vegetable physiology to agriculture are thus seen to be most important, and the great improvements which have of late years taken place in agriculture are mainly due to the increased interest taken in such matters, and the many admirable researches to which it has led. However interesting in an agricultural point of view this connection may be, our necessary limits will not allow us to dwell upon it further.

Section 2. Life of the whole Plant, or the Plant in Action.

The various substances required by plants as food having now been considered, we have, in the next place, briefly to show, how that food is taken up by them, distributed through their tissues, and altered and adapted for their requirements. The consideration of these matters involves a notice of the functions of vegetation, namely, of Absorption, Circulation, Respiration, Assimilation, Development, and Secretion.

The more important facts connected with these have, how-

ever, already been referred to in treating of the Special Physiology of the Elementary Tissues, and of the Root, Stem, and Leaf; so that it now remains only for us in this place to give a general recapitulation of the functions of the plant, and to consider them as working together for the common benefit of the whole.

1. *Absorption.* — The root, as already noticed (see p. 730), is the main organ by which food is taken up in a state of solution, for the uses of the plant. No solid matter can be absorbed in an undissolved condition; and this absorptive power is owing to the superior density of the contents of the cells of the young extremities of the roots over the fluid matters surrounding them in the soil leading to the production of endosmotic action (see page 723, and *fig.* 1098) between them.

That the roots do thus absorb fluid matters may be proved by a very simple experiment. Thus, if we take two glasses of the same capacity, and pour water into them until it is at the same level in each, and then put the roots of a vigorous growing plant in the one, and expose both in other respects to the same influences of light, heat, and air, it will be noticed, that the water will gradually disappear from the glasses, but from that in which the roots are placed far more rapidly than from the other without them, and hence the more rapid removal in the former case must be owing to the absorption of the roots. In this way we can also estimate, in some degree at least, the amount absorbed, which will be found to be very considerable, commonly in a few days, far exceeding in weight that of the plants which are experimented upon. The amount of fluid absorbed by the roots is directly dependent upon the activity with which the other processes of vegetation are carried on, and more especially by the quantity of fluid matters transpired by the leaves; indeed absorption is directly proportioned to transpiration in a healthy plant; for as fluid is given off by the leaves, it is absorbed by the roots to make up for the deficiency thus produced, and hence, therefore, all stimulants to transpiration are at the same time exciters of absorption. When absorption and transpiration vary much in amount, the plants in which such a want of correspondence takes place become unhealthy; thus when transpiration is checked from deficiency of light, as when they are grown in dark places, the fluids in them are excessive in amount; whilst if the atmosphere be too dry, as is the case in plants grown in the sitting-rooms of our dwelling-houses, transpiration is greater than absorption, and hence require to be frequently supplied with water, or otherwise they will suffer from a deficiency of fluid.

The mutual dependence of absorption upon transpiration should also be borne in mind in the process of transplanting trees, &c. Thus, as transpiration is greatest at those seasons of the year

when the plants are most abundantly covered with leaves, and when solar light is most intense, we ought not to transplant at such periods, because as it is almost impossible to do so without some injury to the extremities of the roots (see p. 730), the amount of fluid absorbed cannot compensate for the loss by transpiration, and hence the plants will languish, or die, according to circumstances. By transplanting in autumn or spring, we do not expose the plants to such unfavourable influences, as the light is then less intense, and there are no leaves upon them. (For further particulars on Absorption, see *Absorption of Roots*, p. 730.)

2. *Distribution of Fluid Matters through the Plant, and their Alteration in the Leaves.*—The fluid matter thus absorbed by the roots is carried upwards by their tissues (*fig.* 1117) to the stem, and thence through it to the leaves, &c., as indicated by the arrows in the figure, to be aerated and elaborated, after which it is returned to the stem and descends by the inner bark and cambium layer (*fig.* 1117) of Dicotyledons towards the roots from which it started; and by means of the medullary rays and the general permeability of the tissues of which the plants are composed, it becomes gradually distributed to the different parts of the plant where new tissues are being formed, and where secretions are to be deposited. This general distribution of the fluid matters through the plant is commonly termed the *circulation of the sap.* The fluid as it ascends is called the Ascending or Crude Sap, and as it descends, the Descending or Elaborated Sap. Although the term Circulation is thus commonly applied to this movement of the sap, it must be borne in mind, that the process bears no analogy to the circulation of the blood in animals; for plants have no heart or any organ of an analogous nature to propel their fluid matters, nor any series of vessels in which a flow thus produced takes place. The circulation of the sap of plants is simply a distribution of fluids, and the essential and direct cause is, endosmotic action.

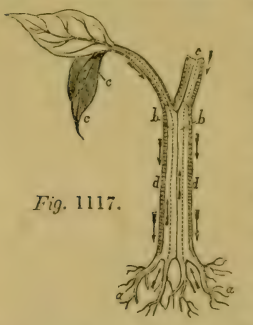


Fig. 1117.

Fig. 1117. Diagrammatic section of the stem of a Dicotyledon, showing the distribution or circulation of the sap. The direction is indicated by the arrows. *a, a.* Roots, by which the fluid matters are absorbed. *b, b.* The tissues by which they ascend to the leaves, *c, c.* *d, d.* Outer portions of stem and bark where the descent takes place. *c.* Section of a branch. After Balfour.

Ascent of the Sap.— The sap in its ascent to the leaves, &c., passes principally through the young unincrusted wood-cells

(p. 726), and therefore in Dicotyledons when they are of any age, through the outer portion of the wood or the *alburnum*. In such plants also, we have but one main stream of ascending sap. In Monocotyledons and Acotyledonous stems, the ascent also takes place through the unincrusted cells of the fibro-vascular bundles; and hence in such plants, and more especially in Monocotyledons, we have a number of more or less distinct ascending streams. In the lower Acotyledons, as Thallogens, which have no stems, there is no regular course of the sap, but the fluids may be noticed flowing in all directions through their cells, and to be more especially evident in those parts which are of a lax nature.

The cause of the flow of the sap in Thallogens and in plants even such as Mosses, &c., which have no fibro-vascular tissues, is simply endosmotic action, arising from the varying densities of the contents of the cells at different parts.

In the higher plants, such as those which have true stems with fibro-vascular bundles, the principal cause of the ascent is, also, endosmotic action. This is probably assisted also, at certain periods, such as in the spring of the year, &c., when the whole plant is gorged with sap, by capillary attraction. (Trécul says that capillary attraction and endosmose are quite insufficient to account for this rise of the sap. He has also put forward some entirely new views regarding the distribution of fluids through the plant, but as these have not been confirmed we cannot explain them here.) The mode in which endosmotic action thus produces the ascent of the sap may be explained as follows:—The fluid contents of the cells of the leaves and other external parts where transpiration or assimilation is going on, become increased in density, and thus act by endosmotic action upon the more fluid contents of the cells within them; these in like manner by becoming thickened, also react upon those below them, which in like way do so upon those beneath, and so on, until the influence is communicated to the cells of the root by which fluid is absorbed from without, and thus the increased density of the fluid contents of the leaves, &c., is the cause of endosmotic action, and this leads directly to the ascent of the sap through the stem. This influence of the leaves in promoting the absorption and ascent of fluid matters is well shown by introducing a branch of a plant growing in the open air in winter, into a hot-house. In this case, as soon as the leaves expand, absorption and ascent of fluid matters immediately take place.

Endosmose being thus shown to be the principal direct cause of the ascent of the sap, the force with which this ascent takes place will necessarily vary at the different seasons of the year, according to the activity of those processes, such as transpiration and assimilation, by which condensation of the fluid contents of the leaves, &c., is produced. Thus in the winter no transpira-

tion takes place, and the cells of the young buds are moreover then filled with watery matters holding starch and other insoluble substances in suspension. The fluids of the plant are therefore in a nearly quiescent state, as there are no changes then taking place to produce their distribution. When the increased heat and light of spring commence, the insoluble starch, &c., become converted into soluble dextrine, sugar, &c., by which the contents of the cells become thickened, development and transpiration immediately follow, which give rise to endosmotic action and a consequent ascent of the sap. This flow continues throughout the summer months, when the causes favourable to it are in full activity; but towards the autumn, as heat and light diminish again, the force of the ascent also diminishes, and the flow of sap is again suspended in the winter months from the reasons above alluded to.

The force with which the sap ascends is probably greatest in the summer months, when heat and light are most intense, and when vegetation is consequently most active; and least in the winter. At first sight it would appear, that the most rapid flow of the sap was in the spring months, at which period alone, plants will give off much fluid, or bleed as it is commonly termed, when their stems are wounded. But this bleeding arises from the plants being then in an abnormal state, for the vessels as well as the prosenchymatous cells are filled with sap, so that the whole plant is, as it were, gorged with it, and thus in consequence of the leaves being not then fully formed, and unable, therefore, to absorb for their use all the sap which the stems contain, such stems will bleed when wounded. But as soon as the leaves, &c., are in full activity, or when the flowers are developed before the leaves, the sap becomes rapidly absorbed, and the current is soon confined to its proper channels — the prosenchymatous cells — and the stems no longer bleed. It by no means follows, therefore, that when the plant is most gorged with fluid matters, and bleeds, that the force of the circulation is most active, but the force is greatest when the stem is least gorged with sap, as in the summer months, when vegetation is most active, and the sap consumed as fast as it can be transferred upwards through the stem.

In a healthy state of the plant, as already noticed (p. 779), absorption of fluid matters by the roots and their transpiration by leaves are directly proportionate the one to the other, and hence all stimulants to transpiration are in like manner stimulants to absorption. In like manner, as we have just observed, the force of the circulation is promoted by transpiration, and thus in a healthy plant in a perfectly normal state, the amount of fluid absorbed by the roots, the force with which it ascends to the stem, and the amount transpired by the leaves, are directly proportionate to one another.

The force of the circulation was measured by Hales in the stem of the Vine by the apparatus represented in *fig.* 1118, where *a* represents a section of a vine stock, to the upper end of which is attached a bent glass tube, *d e f g*, by means of a copper cap, *b*, a piece of bladder, and a lute, *c*. The bent tube being filled with mercury to the level, *e f*, at the commencement of the experiment, the force of the sap was readily calculated by the fall of the mercury in one leg of the tube *d e g*, and its corresponding rise above *f* in the other leg of the tube. In this way he found, that in one experiment, the force of the ascent was sufficient to support a column of mercury upwards of 32 inches in height. He also calculated from his experiments on the Vine, that the force with which it rises in this plant is nearly five times greater than that of the blood in the crural artery of a horse, and seven times greater than that of the blood in the same artery of a dog. In some experiments of Brucke on the force of the ascent of the sap in the spring in the Vine, he found that it was equal to the support of a column of mercury 17½ inches high.

Fig. 1118.

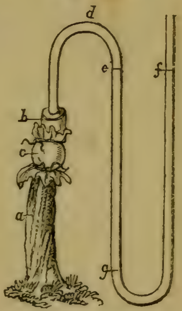


Fig. 1118. Apparatus employed by Hales to show the force of the ascent of the sap. *a*. Cut vine stock. *b*. a copper cap, which is secured to the stock by means of a piece of bladder and lute, *c*.; *d*, *e*, *f*, *g*, bent glass tube attached to the copper cap, and containing mercury, the level of which, at the commencement of the experiment, is marked by *e*, *f*, and at the conclusion in one leg of the tube by *g*; and hence the mercury in the other leg must have risen to a corresponding degree to its depression in the former.

As the fluid rises in the stem it is of a watery nature, and contains dissolved in it the various inorganic matters in the same state nearly in which they were absorbed by the roots. It also contains some sugar, dextrine, and other matters which it has dissolved in its course upwards to the leaves, &c. In its passage upwards, although it becomes more and more altered from the state in which it was absorbed by the roots; when it reaches the leaves it is still unfitted for the requirements of the plant, and is hence called Crude Sap. It undergoes certain changes in the leaves and other green parts, by which it becomes altered in several particulars, and is then adapted for the uses of the plant. In this state it is termed Elaborated Sap.

Changes of the Crude Sap in the Leaves, &c. — The changes which the crude sap undergoes in the leaves by the action of light and air, and by which it becomes transformed into the elaborated sap, have been already particularly alluded to in treating of the Functions of Leaves (p. 734); it will be

here, therefore, only necessary, to state in what those changes consist. They are: — 1st. The transpiration of the superfluous fluid of the crude sap in the form of watery vapour, by which it becomes thickened. This transpiration is not a distinct function, but is simply an accompaniment of the *second change* which occurs in the crude sap, and which is commonly termed *Respiration*. This consists essentially, and perhaps entirely, in the absorption and decomposition of carbonic acid gas, by which carbon—that most important constituent of plants, is added to the crude sap. The *third change* is the formation out of the various inorganic elements present in the crude sap, of the numerous organic products and secretions, which process is properly termed *Assimilation*. The crude sap being thus altered, contains in itself all the various azotized and unazotized substances which are required for the development of new tissues (*Development*), and the different secretions (*Secretion*). It is then termed Elaborated Sap.

The important influences which these changes have in Nature, in promoting the purity of the atmosphere we breathe (p. 739), the healthiness or otherwise of a particular country (p. 736), and the fertility or barrenness of a soil (p. 736), &c., have been already noticed. We have also seen, that in order that these changes may be properly performed, the leaves must be freely exposed to light (p. 741), or otherwise no proper assimilation of the various inorganic substances which they contain takes place, and hence the formation of the various organic substances necessary for the free development of the tissues, and for the production of the secretions, is more or less interfered with.

As light is thus seen to be essentially necessary for the formation of the secretions of the plant, it follows, as we have seen (p. 741), that when the secretions of particular plants which are otherwise agreeable, are injurious, or of unpleasant flavour, that, by growing them in darkness or in diminished light, they can then be used as vegetables for the table, as is the case with Celery, Sea Kale, Lettuce, Endive, &c. For the same reason the plants of warm and tropical regions, where the light is much more intense than it is in this country or in other cold and temperate regions, are commonly remarkable for the powerful characters of their secretions, as is well illustrated by the strong odours of their flowers, and the rich flavours of their fruits, as contrasted with those of cold and temperate climates.

Again, as the production of secretions depends upon the intensity of light, it frequently follows,—that a plant of a warm or tropical region which naturally produces a secretion which may be of great value as a medicinal agent, or useful in the arts, &c., when transported to this or any other climate in which the intensity of the light is much less than it is in its native

country, that secretion is not formed at all, or in diminished quantity. Even if such plants be placed in our hot-houses, where they may be submitted to the same degree of heat as they obtain naturally in their native countries, their secretions are not formed, because light is the main agent concerned in their formation, and we cannot increase the amount of light like heat by artificial means.

Another cause which commonly interferes with the formation of the secretions of plants of warmer regions when grown in our hot-houses, is the want of a proper and incessant supply of fresh air to facilitate transpiration, &c.

The above facts are of great interest, as they have an important bearing upon the growth of plants and fruits for the table, as well as in a medicinal and economical point of view. At present, however, much remains to be discovered, before we can be said to have anything like a satisfactory explanation of the causes which influence the formation of the secretions of plants; for it is found that the same plants when grown in different parts of Great Britain, where the climatal differences are not strikingly at variance, or even at the distance of a few miles, or in some cases a few yards, frequently vary much as regards the nature of their peculiar secretions. A striking illustration of this fact is mentioned by Dr. Christison, who found that some Umbelliferous plants, as *Cicuta virosa* (Water Hemlock), and Hemlock Water Dropwort (*Œnanthe crocata*), which are poisonous in most districts of England, are innocuous when grown near Edinburgh. The causes which lead to such differences are at present obscure, but the varying conditions of soil and moisture under which such plants are grown, have doubtless an important influence upon their secretions. In a Pharmaceutical point of view, as far as the active properties of the various medicinal preparations obtained from plants are concerned, this modification in the secretions of plants by such causes is of much interest, and would amply repay investigation; for it cannot be doubted, but that each plant will only form its proper secretions when grown under those circumstances which are natural to it, and that consequently any change from those conditions will modify to some extent the properties of the plant. I cannot but believe that here we have an explanation, to some extent at least, of the cause of the varying strength of medicinal preparations obtained from plants grown in different parts of this country, or in different soils, &c. We cannot, however, further discuss this matter here; the above is only thrown out as a suggestion for future inquiries.

Descent of the Sap.—After the crude sap has been transformed into the elaborated sap in the manner already described, it is returned from the leaves to the inner-bark and cambium region of Dicotyledons; and apparently to the parenchymatous tissues

generally of the stems of Monocotyledons and Acrogens. It then descends in the stems of the several kinds of plants towards the root, and in its course affords materials for the development of new tissues and the production of flowers and fruit, and at the same time deposits its various secretions. Hoffman in his experiments upon Ferns, however, could not find any path by which the elaborated juices descended in the stem.

In Dicotyledons, the elaborated sap is commonly said to descend through the internal bark and cambium-layer towards the root, and to be transmitted laterally inwards by the medullary rays. (See p. 734, and Functions of Laticiferous vessels, p. 727.) The causes which lead to this descent of the sap are altogether unexplained, indeed, this descent is totally denied by some physiologists; but that a descent of assimilated nutriment does take place is beyond doubt, for otherwise, how could we explain the fact, — that when a ligature is tied tightly round the bark of a stem, or more especially if a ring of bark be removed, no new wood is produced below the ligature or ring, while there will be an increased development above it. Again, it is well known, that by removing a ring of bark from a fruit tree, a larger quantity of fruit may be temporarily obtained from that tree, owing to the larger amount of nutritive matter which then becomes available for the use of the reproductive organs. Another circumstance which also clearly proves to my mind the descent of the nutritive matter, is the fact, that if you peel off the cortical parts of the stems of a potato plant, the formation of underground tubers is prevented. We may conclude therefore, that although we cannot explain the cause or causes which lead to the descent of the elaborated sap, the fact of that descent is undoubted.

CHAPTER 3.

SPECIAL PHENOMENA IN THE LIFE OF THE PLANT.

1. Development of Heat by Plants.—As the various organs and parts of living plants are the seat of active chemical and other changes during their development, and in the performance of their different functions, we might conclude, that their temperature would rarely or ever, under natural circumstances, correspond with that of the atmosphere around them.

We have already noticed, that during the germination of seeds, a considerable development of heat takes place (p. 770). This is more especially evident, when a number of seeds germinate together, as in the process of malting. The development

of heat also, in the process of flowering, has been alluded to (p. 747). The rise of temperature which thus occurs in the processes of germination and flowering, is due, without doubt, essentially, to the production of carbonic acid. We have still to inquire, whether the ordinary vital actions which are going on in plants are calculated to raise or diminish their temperature.

The experiments of Hunter, Schoepf, Bierkander, Maurice, Pictet, and more especially of Schubler, lead to the conclusion, that the trees of our climate with thick trunks exhibit a variable internal temperature, being higher in the winter and at sunrise, than the surrounding atmosphere, — that is, at periods of great cold, or of moderate temperature; and lower in the summer or at mid-day, — that is, at periods of great heat. In no observed cases were such trees noticed to possess exactly the temperature of the atmosphere around them. The experiments of Reaumur on trees with slender trunks exposed directly to the sun's rays, showed a considerable increase of temperature in them over the external air. These experiments of Reaumur are, however, by no means satisfactory.

The temperature of trees under the above conditions depends upon various causes, such as the sun's rays, the amount of evaporation, chemical changes which take place during assimilation, &c., the conducting powers of the wood, and particularly upon the temperature of the soil in which the plants are grown. In the active periods of the growth of plants, when evaporation is constantly going on, and the fixation of carbon taking place, both of which processes are accompanied by a diminution of heat, it is evident, that such changes must have some effect in modifying the temperature, and hence if, at such periods, their temperature be above that of the surrounding air, that it is due to external influences, such as the sun's rays, and the temperature of the soil, &c. This probably explains, to some extent at least, why the temperature of thick trees exposed to great heat, is lower than that of the surrounding air, for at such a period vegetation is in a very active condition, evaporation and assimilation being then in full play. Again, when the temperature of the air is low, as in winter or during the night, but little or no evaporation or assimilation takes place, and hence we find that the temperature is higher in them than the external air.

The conclusions come to in the last paragraph do not, however, altogether agree with the published result of experiments made by Dutrochet; for he found, by operating with Becquerel's thermo-electric needle, that when plants were placed in a moist atmosphere so as to restrain evaporation, that a slight increase of temperature took place, and thus seeming to prove that the chemical changes taking place in plants produced a rise rather than a diminution of temperature. Probably this slight increase of heat under such circumstances is due to an oxidation or com-

bustion of a portion of the carbon of the plant. Dutrochet found, however, that when evaporation was allowed, that the proper vital or specific heat of plants was slightly below that of the atmosphere. He also noticed that the heat of plants varied during the course of twenty-four hours, the hour of maximum temperature varying from ten in the morning to three in the afternoon, the minimum occurring at midnight. The variation, however, in such cases was extremely small in degree, being only from about one-tenth to a little over one-half a degree of Fahrenheit. This specific heat of plants could only be observed by him in green and soft structures, those which were hard or woody not possessing any specific heat. The above is but a brief summary of the conclusions which have been at present arrived at with regard to the development of heat by plants, and even these are by no means of a satisfactory nature. Much further investigation is required upon the development of heat by plants.

2. Luminosity of Plants. — But very little is positively known respecting the development of light by plants. It seems, however, tolerably well ascertained, on the authority of Humboldt, Nees von Esenbeck, Unger, Drummond, and others, that the thalli of some living Fungi are luminous in the dark. This luminosity has been noticed in several species of *Agaricus* and *Rhizomorpha*. According to Prestoe, the mycelium of the common Truffle is also luminous in the dark.

The statement that certain Mosses, as *Schistostega osmundacea* and *Mnium punctatum*, were phosphorescent, appears to be founded on imperfect observation.

With regard to the development of light by the higher classes of plants, we have at present no very satisfactory observations to depend upon. It has, however, been repeatedly stated, that many orange and red-coloured flowers, such as those of the Nasturtium, Sunflower, Marigolds, Orange Lilies, Red Poppies, &c., give out, on the evening of a hot day in summer, peculiar flashes of light. This peculiar luminosity of orange and red flowers is now commonly regarded as an optical delusion, and the fact of such luminosity having been only noticed in flowers with such bright and gaudy tints, appears strongly to favour such a conclusion.

The rhizomes of certain Indian grasses have been reported to be luminous in the dark during the rainy season; and Mornay and Martius have observed, that the milky juices of some plants were luminous when exuding from wounds made in them. Martius also states, that the milky juice of *Euphorbia phosphorea* is luminous after removal from the plant, when it is heated.

3. Electricity of Plants.—All the statements which have been made upon the electrical condition of plants are vague and unsatisfactory. It is said by some that electricity is developed during the ordinary growth of plants, as in germination

and exhalation. Plants are also stated to be commonly in a negative condition as regards their electricity, but that different parts of plants may exhibit opposite electrical phenomena.

4. MOVEMENTS OF PLANTS.—Three kinds of movements have been described in plants:—1. Motions of entire plants, such as those which occur in the Oscillatorieæ, Diatomaceæ, and some other forms of the lower Algæ; and of parts connected with the reproductive processes in some of the lower kinds of plants. The locomotive power thus possessed by some of the lower Algæ is a marked deviation from what ordinarily occurs in vegetables. 2. Movements produced in parts of plants which are dead, or which, at least, have lost their active vitality. Such movements may be noticed in almost all the great divisions of plants, and are more or less connected with some reproductive function. We include here, the bursting of anthers in the higher classes of plants, and that of spore-cases in the lower; the dehiscence of fruits, the separation of the component carpels from each other in the Euphorbiaceæ and Geraniaceæ, and many other phenomena of a like nature. 3. Movements which occur in the living parts of plants when in an active state of growth, &c.

The first two classes of movements have been already alluded to in various parts of this work. The movements of the first class appear to depend upon a rotation of the protoplasmic cell-contents, the cause of which is at present unexplained; or to the presence of cilia upon their surfaces. Movements of the second kind are entirely mechanical, and produced by the varying conditions of the different tissues as to elasticity and power of imbibing moisture.

The third kind of movements must be more particularly noticed. They only occur during active vegetation. The directions taken by organs properly come under this head. This matter, so far as the Plumule and Radicle are concerned, has been already noticed (p. 771). We shall not further allude to this portion of the subject. The remaining movements belonging to this class have been divided by Schleiden as follows: —

1. Movements which evidently depend on external influences. These are again divided into two: —
   a. Periodical.
   b. Not periodical.
2. Movements independent, at least to some extent, of external influences, which are also divided into two: —
   a. Periodical.
   b. Not periodical.

1. MOVEMENTS DEPENDING ON EXTERNAL INFLUENCES.—*a. Periodical.*—Under this head we include such movements as

those of certain leaves, and the petals of flowers, which occur at particular hours, and which remain in the new position thus taken up until the return of a particular period, when they resume as nearly as possible their original position. In leaves, these periodical movements consist in the closing up of such organs towards the evening and their expansion in the daylight. In the petals of flowers great differences occur in different plants, some opening or closing at particular hours of the day; and thus, by observing these changes in a variety of flowers, Linnæus and others have drawn up what has been termed a floral clock. This periodical closing up of leaves and flowers has been called the sleep of plants. The compound leaves of certain Leguminosæ and Oxalidaceæ are marked illustrations of these periodical movements. All the above movements are indirectly dependent upon the varying conditions of light to which the parts of the plant in which they are found are exposed.

b. Not periodical.— Such movements are exhibited in a number of plants both in the leaves and in their reproductive organs. In the leaves they are well seen in certain species of *Oxalis*, *Mimosa* (*fig.* 350), in *Dionæa muscipula* (*fig.* 352), &c. In the Reproductive Organs they may be noticed in the curving inwards or outwards of the stamens of certain plants, such as those of *Berberis vulgaris* and other species, *Parietaria judaica*, *Helianthemum vulgare* and other Cistaceæ; also in the stigmas of the Lobeliaceæ, &c.; and in the style of *Goldfussia anisophylla*, *&c.* All the above movements are produced by external agency, such as the action of insects, the agitation caused by the wind, &c.; and the immediate object of such movements is evidently to bring the pollen into connection with the stigma.

Fig. 1119.

Fig. 1119. A portion of a branch, and the leaf of *Desmodium gyrans*. The leaf is trifoliate, and consists of a large terminal leaflet, *a*, and two smaller ones, *b*. There are two other rudimentary leaflets, marked also *b*, near the terminal leaflet, hence the leaf would be perhaps better characterised as *imparipinnate*.

2. Movements independent, at least to some extent, of external Influences.—*a. Periodical.*—These movements are seen in the leaflets of certain tropical species of *Desmodium* (*Hedysarum*), and more especially in those of *Desmodium gyrans* (*fig.* 1119).

The leaf in this plant is trifoliate, the terminal leaflet, *a*, being much larger than the two lateral leaflets, *b*. The large terminal leaflet, *a*, when exposed to the influence of a bright light, becomes more or less horizontal, but it falls downwards on the approach of evening. Such movements are therefore clearly analogous to the sleep of plants previously described. The lateral leaflets, *b*, exhibit a constant movement during the heat of the day, advancing by their edges towards the large terminal leaflet and then retreating towards the base of the common petiole. This movement takes place first on one side and then on the other, so that the point of each leaflet describes a circle. These movements resemble those of the arms of the old semaphore telegraphs, and hence this plant has been termed the Telegraph plant. These movements go on to a less extent even in the dark. They are most evident when the plants are in a vigorous state of growth, and when exposed to a high temperature. No satisfactory explanation has as yet been given of the direct cause of this movement.

b. Not periodical.—These movements occur in the reproductive organs of a large number of the Phanerogamia, and their object is clearly to transfer the pollen to the stigma. The stamens sometimes curve inwards separately towards the stigma, as in *Ruta graveolens* (*fig.* 596), and *Parnassia palustris;* or in pairs, as in *Saxifraga tridactylites.* After the pollen is discharged, the stamens commonly return as nearly as possible to their former position. In *Passiflora*, *Nigella sativa*, certain Onagraceæ and Cacti, &c., the styles move to the stamens; while in other Onagraceæ and certain Malvaceæ, &c., both styles and stamens move towards each other. No explanation of a satisfactory nature has been given of the cause of these movements.

GENERAL AND GLOSSARIAL

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TO

STRUCTURAL AND PHYSIOLOGICAL BOTANY.

*** The technical terms mentioned below are explained at the pages referred to, and thus the Index may be used as a Glossary.

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